AGRICULTURAL ENGINEERING

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Low-Cost Corn

CORN-BELT farmers are fitting general-purpose tractors, rubber tires, attachable equipment, hybrid varieties, and sound production practices into programs of operation for efficient, low-cost corn production. In terms of farming they are fighting to raise corn for less than the selling price, as much less as possible; to raise feed for less than it would cost them to buy it; to earn a good living by meeting a basic market demand for low-cost corn with corn produced at a still lower cost.

In terms of economics they are increasing real wealth by decreasing the other values consumed in the creation of values in the form of corn; and by making corn more widely usable by reason of its low cost, as a food, feed, and raw material for processing industries. In terms of employment, they are increasing the demand for skilled labor on farms, in farm equipment factories, and in industries processing farm products, while decreasing the demand for poorly-paid unskilled labor. In terms of living costs they are giving consumers, farm and city, more necessary and luxury goods per dollar without basing their bargain on underpaid labor, capital, or management.

Agricultural engineering is involved both in creation of the equipment and in furthering its efficient use to achieve these ends.

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Moist Air Farming

THE "moist air" concept of farm products, as developed in connection with its agricultural engineering implications by Arnold P. Yerkes in his recent address (published in this issue) as president of the American Society of Agricultural Engineers, is not so facetious or far-fetched as it may sound on first impact.

It is elementary biochemical knowledge that the elements most prevalent in organic materials are carbon, oxygen, hydrogen, and nitrogen obtained either directly or indirectly from air and water. Other elements, originating in the soil rather than in air are present, of course, but in much smaller quantities.

Another elementary chemical fact, as pointed out by Mr. Yerkes, is that, of all the thousands of organic products provided by nature, with or without the assistance of man, the predominantly important ingredients belong to one or another of a comparatively few types of chemical compounds. They are cellulose, starch, sugar, oil, protein, or some combination of these and other classes of compounds. And organic chemists have made considerable progress, not only in synthesizing elementary organic compounds from inorganic materials, but in physically and chemically changing the characteristics of compounds produced by one plant or animal to create the identical compounds and combinations of compounds produced by other plants or animals, or products sufficiently alike to be commercially competitive.

Heretofore the agricultural commerce of the world has been limited by the characteristics and environmental requirements of plants and animals; by the conditions under which various plants would synthesize air and moisture; by the products into which these were originally synthesized by plants and to some extent resynthesized by animals; and largely by demand for feed and food purposes.

Now organic chemists are pointing the way to supplement natural synthesis; to meet existing and new market demands with natural products grown near the market and chemically and physically modified to order.

From Alaska to Argentina, from Paducah to Patagonia, from timberline to ocean floor, plants are synthesizing, largely from the elements in air and water, the varying types and qualities of cellulose, sugar, starch, proteins, and oils wherewith man works, plays, lives, dies, and lives on in new generations. And we are just beginning to understand these complex chemicals enough to catch the vision that peanut oil might be modified by man, on occasion, to give it the characteristics of palm oil, or any other oil. In other words, any organic material produced in any part of the world might be duplicated or approximated by some material in the same general chemical family, produced anywhere else in the world.

This may be expected to become commercial practice to the extent that it can compete, in terms of cost and quality, with natural production and transportation.

To processors and ultimate consumers this would seem to mean a wider selection of materials available for use to accomplish any desired end, less dependence on any one farm crop, and decreased fluctuation in price due to fluctuation in supply.

For farmers it indicates a wider choice of marketable crops and livestock from which to build a production program best suited to any particular farm and its market, together with a market advantage of wider usefulness for commodities subject to chemical or physical modification.

For agricultural engineers it suggests a wider range of service, rich in opportunities to help farmers and farm product processors serve widening markets.

As a practical possibility for increasing the quantity and variety of marketable commodities derived from farming; for increasing the farmer's economic service to consumers; and for increasing the range and flexibility of farm production programs, chemical developments in the modification of biological commodities would seem to warrant all the help agricultural engineers can give to reduce them to commercial practice.

The "moist air" concept of farm products is truly a liberating idea. It is a reminder that nature has given man a lot to work with in the form of widely distributed elements necessary to life, and in the form of plants which can synthesize these elements into various compounds, which in turn are subject to further change, by man's inorganic means, to meet human needs and desires. The rest is up to man.

Agricultural Engineering in Forage Handling

FORAGE crop handling is being reduced to a sound basis of engineering economics by such leaders as Frank H. Hamlin, who has a paper on the subject in this issue.

No claim is made that a new method of handling forage has been worked out that is better and cheaper than all previous methods under all conditions, or that all forage will ultimately be put up as silage, rather than as hay. The engineering significance of the work being done is that definite operating and investment costs for various specified methods and conditions are being worked out. All important cost items and other considerations are being taken into account. The work is being done in cooperation with scientists in the field of animal nutrition, and is being carried to its logical conclusion of making usable information easily available to farmers in several extension bulletins.

This provides the individual farmer with a basis for an intelligent decision as to what method (or methods) and equipment may be most economical for his particular situation as to type and scale of operations, labor supply, existing equipment, and availability and cost of additional capital.

This is far from the only available example of its kind, but we would like to see still more of this sort of getting down to brass tacks in the matter of farm production economy, with specific indications to farmers of what costs and results they may expect with what equipment they have and can get. Agricultural engineering developments do not represent real accomplishment until they are translated into practical, profitable farm use.

Electric Load Possibilities

USE OF electric power for irrigation purposes in the year-round agriculture of California provides a rural power demand there that far exceeds the rural demand in most other parts of the country, as shown by the A.S.A.E. annual meeting paper of E. G. Stahl, published elsewhere in this issue.

This example of a situation in which agricultural engineers and farmers have worked together to make rural electrification profitable to both farmers and the electric company, stands as a challenge to the rest of the country.

Perhaps few, if any, other sections of the country offer a comparable opportunity for profitable use of a corresponding amount of power for any one purpose. Other sections, however, do offer opportunities for a multiplicity of electric uses which could profitably total as great an annual load per acre, or per mile of line, and with a better load factor from the standpoint of both the farmer and the utility.

The criterion of profitable farm electric load is an aggregate of uses in which electricity furnishes the best available form of power, light, or heat by reason of its low cost, labor saving, convenience, ease of control, cleanliness, safety, freedom from trouble, use of wave energy, or other characteristics; and where these advantages are directly reflected in net farm income by reason of lower cost, improved quality of product, increased production, decreased waste, or enabling the farmer to put increased service into his products and sell them more nearly in the condition demanded by consumers.

One of the apparent difficulties in getting farmers to use more electricity and realize its advantages is that most farmers are not yet used to producing commodities of highly standardized quality with the aid of accurately controlled production conditions, with efficient utilization of highly valued time, or to planning for a net income on the basis of units produced times the difference between cost and selling price.

Mr. Stahl's paper shows that his company has followed a farsighted policy of helping farmers of its area with the engineering problems involved in making the most of a special situation. A similar farsighted policy adapted to other special and general situations in other parts of the country, with particular attention to helping farmers profit by more accurately controlled operations, may be expected in time to more than justify many of the rural lines being built by utilities where farms offer less ready-made loads.

Educational Waste

EVIDENCE as to some weak points in the older branches of higher education has recently been compiled and published by the American Council on Education[1].

The report points out that education for the professions has become costly but that little or nothing has been done to "examine the social need for trained men and women in all these professions and to plan educational opportunities for preparation in some relation to present and probable future demands for these services. . . . . Local institutionalism, and the habit of looking upon state political boundaries as also educational boundaries, have prevented any very serious attempts to think in terms of regional provision for these services."

In discussing engineering education, the report refers to cases of strong departments in certain branches of the profession in schools far removed from regional needs for their graduates, and curricula with only one or two graduates per year representing high overhead per unit of output.

Grouping the fields of research, the report mentions wasteful dispersion, disjointed effort, and duplication as factors reducing research achievement per unit of cost.

It is suggested that some of the newer and rapidly developing branches of engineering may profit by the experience of the older branches, and by cooperation and intelligent planning, eliminate some of this educational waste from their future activities.

Agricultural engineering comes within the classification of new and rapidly developing branches of the engineering profession. Its federally supported research in the land-grant agricultural experiment stations is being effectively coordinated through the U.S.D.A. Office of Experiment Stations. From the implications of the report cited, it might be desirable for the College Division of the A.S.A.E. to consider additional ways and means by which the independent research in agricultural engineering departments of the land-grant colleges and universities, together with their other educational activities, may be coordinated to most effectively meet regional needs with the funds and facilities provided. Certainly the funds provided are small enough in proportion to the need, to warrant extreme care that they be used efficiently; and engineers, of all people, should practice within their profession the efficiency they advocate to the world.

[1] "Cooperation and Coordination in Higher Education," Series I, Vol. II, No. 5. American Council on Education.

For More and Better Engineering

PERHAPS the strongest potential support of engineering progress is that large and demanding body of modern malcontents who complain if their train is late, if the streets are rough, when jobs are scarce, when the telephone is out of order for five minutes, or when food prices bounce.

What they really want, whether they know it or not, is the benefit of more and better engineering.

Let engineering be interpreted to the public so that they do know that it can give them the better goods and services they want, and the eloquent vehemence of their demands, their aggregate word power, should far outdecibel the prophets of an engineer-doomed civilization.

Tomorrow's Challenge to Agricultural Engineers

By Arnold P. Yerkes

THERE IS good reason to believe that within a few years there will be a great reduction in the age-old and still prevalent practice of nations transporting moist air halfway round the world and exchanging it for some other moist air to be hauled back again. Carrying coal to Newcastle may seem like quite a rational procedure compared with much of the transportation of moist air—call it starch, or cellulose, or sugar, or copra, etc., if you please—which is being done today.

If this happens, it is certain to produce tremendous changes in our national economy and also many new problems for agricultural engineers.

Change is just as certain as death and taxes, so it is always safe to predict a change. Just how extensive this one will be and how rapidly it will take place is not so easy to forecast. For that reason, it seems desirable that members of this Society, particularly the younger ones whose lives and work may be most affected, should give some careful thought to this matter. This will not only make it easier to solve some of the new problems which will present themselves, but should greatly increase the value of the services which agricultural engineers will be able to render to coming generations.

ARNOLD P. YERKES
President, American Society of Agricultural Engineers 1937-38

At one time, all vegetable matter was supposed to be a product of the soil. This was a very natural assumption. Plants sprang from the soil and their roots permeated the soil, gathering moisture and supposedly the materials which composed the plants.

We learned several years ago, however, that about 97 to 99 per cent of all plants—the cellulose, starch, sugar, and protein—actually came from the air. And chemical research has been constantly learning new facts about the composition of these materials, indicating that cellulose, or starch, or protein, from one plant may often be easily and cheaply converted into materials almost identical with those from plants which are entirely dissimilar in appearance.

The importance of these discoveries and their probable effect upon our domestic and foreign commerce in farm crops, especially those used for industrial purposes, and consequently upon farming practices in many sections, has been realized very slowly. They are by no means fully appreciated at present, but there are numerous indications that they are likely to be in the near future.

In the Agricultural Adjustment Act of 1938, which became a law on February 16, 1938, appears the following:

> Sec. 202. (a) The Secretary is hereby authorized and directed to establish, equip, and maintain four regional research laboratories, one in each major farm producing area, and, at such laboratories, to conduct researches into and to develop new scientific, chemical, and technical uses and new and extended markets and outlets for farm commodities and products and byproducts thereof. Such research and development shall be devoted primarily to those farm commodities in which there are regular or seasonal surpluses, and their products and byproducts.

When this program gets under way, it is certain to produce a wealth of new information which will greatly extend our present ability to substitute one kind of moist air for another.

The U. S. Department of Agriculture has been carrying on considerable research work along this line for several years, and some of it has already borne fruit. Many of our state colleges have been doing similar work, as have also numerous industrial concerns and individual chemists.

A number of new processes developed by these studies are already in commercial use, while others seem certain to be in the immediate future. Furthermore, this country is not alone in its efforts along this line. Other nations are vigorously prosecuting similar research, in some cases for reasons more urgent than ours.

For example, note the following extract from a publication of the U. S. Department of Agriculture, "The Agricultural Situation," for May, 1938—last month:

> German imports of cotton—especially of American cotton—have declined in recent years. From 1933 through 1937, net imports from all sources dropped from 1,669,000 bales to 1,129,000 bales—a reduction of 540,000 bales within 5 years. Most of the reduction was in imports of American cotton.
>
> Reason for the decrease is to be found in the increased German production of textile raw materials—from 47,000 short tons in 1933 to 227,000 in 1937. Production of staple fiber ("vistra") alone, in 1937, was equivalent of more than 500,000 bales of cotton.
>
> The German Institute for Business Research has estimated that whereas production of textile raw materials in 1932 was only about 5 per cent of consumption requirements (a relationship which had been maintained practically since the World War), production in 1937 was more than 22 per cent of domestic consumption.
>
> For more than 20 years, Germany has been experimenting with the use of wood cellulose in the production of artificial textile fibers. Processes of manufacturing continuous filament rayon were developed; but it was not until the advent of its program of self-sufficiency that Germany attempted production of staple fiber on a large scale.
>
> Within five years, from 1933 to 1937, the production of staple fiber was increased from less than 6,000 short tons to more than 110,000 short tons. Meanwhile, production of rayon increased from 31,600 short tons to 62,800 short tons. A further substantial increase in production of these fibers is indicated for 1938 by recent additions to plant manufacturing capacity.

Here is the case of a large nation cutting down very materially on the quantity of cotton fiber, which is almost pure Southern air, which it buys from the United States. Of course, there is a possibility that this is an exceptional case and is due to certain factors which are quite unusual. On the other hand, there is also the possibility that Germany is setting an example which will soon be followed by many other nations.

Address of the President of the American Society of Agricultural Engineers before the annual meeting of the Society at Asilomar, Pacific Grove, Calif., June 28, 1938.

Author: Editor, "Tractor Farming," International Harvester Co. Mem. A.S.A.E. (President A.S.A.E., 1937-38)

AGRICULTURAL ENGINEERS JOIN WITH CHEMISTS, FARMERS, AND INDUSTRIALISTS IN DEVELOPING WAYS OF AIDING AND FURTHERING THE WORK OF NATURE IN SYNTHESIZING AIR AND MOISTURE INTO MORE AND BETTER PRODUCTS FOR HUMAN USE AND MARKET DEMAND, AT LOWER COST AND FOR WIDESPREAD PROSPERITY

However, we do not need to go outside of the United States for examples of the substitution of one kind of moist air for another kind, which will result in important changes in our domestic and foreign commerce and which place new problems before the agricultural engineer. We have numerous examples of this kind right at home.

Our cellulose industry is just one of many which might be cited, but it is perhaps one of the most important. The substitution of wood cellulose for cotton cellulose has already made great progress here, just as it has in Germany, and there is every indication that this will continue.

It is reported that rayon is even being experimented with for rubber tire manufacture—a use for which only the very highest-grade cotton fiber has been suitable and one for which it has been commonly believed no artificial product could compete. While the results are not known at this time, it seems safe to believe that such an experiment was not undertaken unless the men making it thought that it had a fair chance of being successful. Even if it fails at this time, when we consider the tremendous improvement which has been made in rayon fiber during recent years, and which there is no reason for believing has reached its limit, it seems highly probable that rayon tires are not far away.

This situation, along with the development of processes for making many grades of paper out of Southern pine, indicates a far-reaching change in Southern agriculture. A permanently smaller cotton acreage seems probable and the growing of Southern pine as a farm crop on much of the rough and less fertile land of the old Cotton Belt, as a source of cellulose and paper pulp, may become an important industry.

If so, it means many new problems for the agricultural engineers to solve in connection with the growing and handling of a wood crop and probably in the utilization of byproducts.

It may not be amiss to point out right here that one of the new uses for what was formerly waste wood involves engineering processes only—no chemicals whatever are employed. The process consists simply of reducing the wood to chips which are placed in a tank and subjected to steam at high temperature. The pressure is suddenly released and the wood literally explodes into tiny fibers. Water is added and the fibers are formed into thin sheets, several of which are placed one upon the other, depending upon the thickness of material desired, and subjected to heavy pressure between hot platens. The resulting material resembles hard rubber or bakelite and is superior to them in some respects. It is not only better than wood for many purposes, but is suitable for hundreds of uses for which wood is not satisfactory.

This certainly suggests the possibility of developing other valuable processes for utilizing cellulose from farm crops by extending engineering research along similar lines.

Starch is another variety of moist air which many nations, including our own, have imported in large quantities from distant parts of the world, often in exchange for other kinds of moist air or the money received for same.

Doesn't it remind you of the importation of English brick in the early days of the colonies when there was an abundance of excellent brick clay on this side, often on the very banks of the river where the imported article was unloaded? Many of you have doubtless seen the house once owned by William Penn which still stands in Philadelphia, made of imported brick.

After it was discovered that brick could be made out of American clay, the importation of brick soon ceased. It seems highly probable that when we really awake to the fact that American air in the form of starch is just as good as any foreign air in the form of starch there will likely be less of this commodity imported.

The United States has for years been one of the largest producers and exporters of starch in the form of wheat, corn, and other grains. However, if it is desirable, for some particular purposes, to have some of our starch in a different kind of package or at a lower cost, this can easily be accomplished by increasing our acreage of sweet potatoes, for example. If this should prove to be the case, the agricultural engineers will have some new problems in developing more efficient field equipment for sweet potatoes and perhaps in devising storage and processing equipment.

The situation with regard to our imports and exports of moist air in the form of vegetable oils is rather complicated. At one time, practically all the soap made in this country was made by housewives, using animal fats and lye leached

from wood ashes. Later, soap-making became almost entirely a factory process, supervised by chemists. Vegetable oils were substituted for a large part of the animal fats and various chemicals for the lye.

For years, we have imported large quantities of olive and palm oils, and of copra from which we obtained cocoanut oil, for soap-making. Some corn oil and other vegetable oils produced in this country have been used, and the chemists now tell us there is no good reason why they should not be used much more extensively, if not exclusively.

With the constantly increasing knowledge of methods for changing one oil into a satisfactory substitute for another, this seems a reasonable probability.

A soap made from corn or peanut oil may not sound as romantic to the ladies as soaps made from olive or palm oil, but the chemists tell us it is just as good, and many people have used it without noticing any difference. According to the chemists, the important point in any oil used in soap-making is its complete saponification and the absence of free alkali. If this is obtained with oil from corn, or cottonseed, or soybeans, or peanuts, or Southern pine, or any other kind of moist American air, the resulting soap is of equal quality to soap made from moist air from olive orchards or palm groves.

There are two important points to keep in mind in connection with this situation. The first is the fact that chemists have already made great progress in developing means for changing oil from one kind of a plant so it can be substituted for, and serve equally as well as, oils from other plants. The second is the fact that when such substitutions are made on a commercial scale it almost invariably means some new problems for agricultural engineers to tackle.

The situation in the paint and varnish industry is much the same as with the soap industry. At one time, most of the oil used for the manufacture of paint in this country was of domestic origin—largely linseed. More recently, we have been importing large quantities of moist air from various parts of the world for the production of our paints, varnishes, and enamels. Most of the linseed oil, which is still used extensively, comes from abroad.

Tung oil, which is most desirable for quality products, has been brought from the Orient. For years it was regarded as being in a class by itself, there being no other oils known which could compete with it, even though the oriental product varied greatly in quality and a relatively small percentage was of first grade.

However, the chemists have now developed a substitute for tung oil which can be readily made from American air. It is no other than that friend of our childhood days—castor oil. Dr. Harry Miller, a member of this Society, is authority for this statement: "The chemical structure of castor oil is such that by suitable chemical treatment, it can be converted into a product practically identical with tung or China wood oil, and at least two American and several German companies are now marketing such a product. Thus the vast paint and varnish oil market is opened to castor oil."

This means that the agricultural engineers are faced with several new problems, for it seems a practical certainty that castor beans will soon be produced in quantities in the United States, provided the engineers can devise suitable equipment for planting, cultivating, and harvesting.

Its production here seems all the more certain because it has also been found that the stalk contains a fiber which gives promise of becoming valuable. The inner stalk can be converted into a very high-grade, high alpha-cellulose material which is far more absorbent even than cotton. And, believe it or not, many varieties are eaten greedily by grasshoppers which promptly die, apparently from the effects of an alkaloid which it is believed can be removed and probably used as an insecticide. That should be enough, but, in addition, the protein remaining after the oil has been removed from the beans is useful in the production of protein-type plastics, makes a good fertilizer, and, if the alkaloid is removed, may be suitable for feed.

Many of you will recall that during the World War castor oil was in great demand as a lubricant for airplane engines, due to its excellent lubricating properties and resistance to decomposition by high temperatures. At that time, it had some undesirable characteristics, but the chemists have learned how to eliminate them, and in England a blend of castor oil and petroleum oil has been marketed for several years as an automotive lubricant which has been well received by the motoring public.

Add these things up and you can readily see why farmers in this country may soon be demanding of you equipment which will permit them to convert American air into castor bean plants to serve the American people in several ways besides the one with which you are most familiar.

These are just a few of many examples which could be cited showing the changes which are likely to take place in our domestic and foreign commerce in moist air of different kinds. There is another development of a slightly different character which merits your careful consideration. This is the matter of feed for many of our domestic animals, particularly dairy cows.

For years, many farmers have bought large quantities of concentrates or high protein feeds, such as cottonseed meal, oil cake, etc. The volume of such business has been considerable. These feeds have been used to supplement home-grown feeds which were deficient in protein, especially hay.

Hay has ranked high in both acreage and value among our farm products. For the most part, we are still making it just as was done in earliest history. But sun curing is very uncertain and, at best, destroys or wastes much of the feeding value. That was largely the reason so much work has been done in attempting to develop methods of drying grass artificially.

Attempts have also been made over a long period of years to convert grass into silage, but for the most part with uncertain and often unsatisfactory results. Recently, however, it has been found that by simply adding either acid or sugar to any of the common grasses or legumes, excellent silage can be produced.

These processes offer many advantages over the old method of making grass into hay. Fire hazard is reduced, less storage space is required, there is no loss from rainy weather, less labor and expense is involved, injury of the growing crop is reduced, and practically the entire feed value of the crop is retained.

Most important of all, perhaps, is the fact that with this process high protein legumes can be converted into good silage just as readily as non-leguminous crops. This will undoubtedly mean an increase in the acreages of alfalfa, lespedeza, sweet clover, soybeans, cowpeas, etc. There is also the possibility of earlier and perhaps more frequent cutting being made of some crops, which usually means a higher percentage of protein.

The extensive use of grass silage is therefore certain to have a profound effect upon the shipments of high-protein feeds from one part of the country to the other. In fact, it is likely to reduce the transportation of moist air, both nationally and internationally.

Two years ago this process was practically unknown to farmers. Last year, grass silage was produced on thousands of farms and the results were so satisfactory that the practice is being greatly extended this year, and it seems almost a certainty that it will continue to expand rapidly.

An indication of the interest which farmers are taking in this new process was furnished recently when a single sentence in an article appearing in a farm paper, referring to a machine for taking grass from a windrow and chopping it ready for the silo, brought over 7,000 letters from farmers asking where such a machine could be obtained.

If the making of grass silage becomes general, there will be a number of new problems for agricultural engineers to solve. New field equipment will be required for handling the grass. Some work has already been done along this line, but much remains to be done.

Two old and unsolved problems will become more insistent in demanding a solution—a more satisfactory and economical seal for silos, and an easier and more economical method of removing silage from the silo and feeding it to the animals. If men must continue to go into the silo each time a supply is needed, then the engineer who devises a safe, convenient elevator, to eliminate the frequent, irksome ladder climbing now required, will receive a vote of thanks from farmers.

The ability to make good silage out of grass should be a great help in the program of soil conservation. Grass yields are of course highest in sections having the greatest rainfall, and soil erosion is at its worst in these same sections, while hay curing has been most difficult under these same conditions. The possibilities in this direction need no elaboration to this group.

As methods for making more extensive and more efficient use of American air are developed and put into commercial use, it would be highly desirable if we could establish better control over the moisture needed to produce plants from the air. Agricultural engineers have already done some very commendable work in removing surplus moisture from wet land, irrigating dry areas, and regulating runoff to reduce soil erosion. Dr. M. L. Nichols has told you that a great deal more work is needed on agricultural hydrology in connection with soil conservation measures. It seems probable that this work will have to be carried even farther, or perhaps it would be more accurate to say "deeper", in attempting to learn more about the underground movement of water and controlling to some extent the levels of the water tables from which we shall need to pump irrigation water to insure a reasonably uniform supply of moist air for industrial uses.

While there are no data on the water table levels which existed either in the virgin timbered areas, the prairie sections, or in the Great Plains when this country was settled, we do know that in recent years these levels have dropped considerably in many places. It seems probable that this is due in part to our interference with nature's engineering projects. We know that nature provided billions of conduits from the surface to the lower soil strata. Tree roots, burrowing animals and insects built them. We have not only destroyed most of them, but have prevented the formation of new ones. It may be that some of nature's children can teach us some things about underground drainage which will be valuable. Many animals can remain in underground living quarters even though water is flowing into the surface entrances. Do they use suitable strata for drainage purposes?

There have been sufficient instances where ponds and small lakes have been drained by boring into the soil to a water-carrying stratum to indicate that there is at least a possibility of diverting a great deal of water underground and perhaps controlling to at least some slight extent the water table levels. At any rate, there is very evidently a need for extensive research into the possibilities along this line.

The success of W. W. McLaughlin, of the Bureau of Agricultural Engineering, U. S. Department of Agriculture, with underground storage of water under some California conditions, has been such as to indicate real possibilities along this line in other sections.

This is just a brief outline of some of the new work which will confront the agricultural engineer of tomorrow. There is a great deal of research now in progress, both in agricultural engineering and in other branches of agricultural science, that is likely to add materially to the list in the near future. The opportunities for the agricultural engineer to serve farmers and the nation are therefore certain to be much greater in the future than in the past.

Agricultural engineers have rendered a great service to this nation by increasing the efficiency of farm labor and thereby adding immensely to the nation's wealth. For the wealth of this or any other nation lies principally in the productiveness of its labor—in the amount of useful goods which can be produced. By making it possible for a smaller percentage of the population to produce the necessary food and fiber, the agricultural engineer has at the same time made possible the development of our city industries and the arts and sciences. It is surely no reflection upon the agricultural engineer that other industries have not been able at all times to absorb the excess farm population, and we occasionally find ourselves with a greater quantity of agricultural products than can be consumed in the ordinary channels.

However, if agricultural engineers can extend their services so as to make possible and practicable the utilization of farm crops for new uses—for the production of semi-permanent goods instead of merely for food and clothing—this will be well worth while and this represents a challenge which should merit the earnest consideration of this Society.

Blowers for Frost Protection

By Ben D. Moses

IT HAS been a matter of common observation that frost does not generally occur on windy nights. With this in mind, efforts have been made to create artificial wind, and in some instances even to heat this wind, to protect orchards against frost damage.

Large blowers or fans mounted on towers as high as 50 ft above the ground have been used in California for twenty years. Some of these are driven by electric motors and others by gas engines, varying in size from a Ford V-8 engine to a 425-hp airplane engine. The greatest use of this equipment has been in the central California citrus district, but the practice has been extended to other areas, and a few installations have been made in walnuts, apricots, and pears.

Our own observations and the experiences of owners indicate that under certain conditions blowers have definitely reduced frost damage. Temperature observations in some instances have shown the air to be at least 3 degrees warmer within the range of blowers than that outside. In the winter of 1934-35 where the oranges in two orchards were graded for frost injury, it was quite evident that the fruit nearest the blower was damaged least, and that the damage increased with the distance from the blower. Similar results were later obtained in a walnut orchard.

Due to friction, turbulence, and convection, the effectiveness of blowers decreases rapidly beyond 300 ft for small machines and 500 ft for large ones. The difficulty of mixing heated air with the cold air of the orchard increases with their temperature difference.

When blowers are used, best practice indicates that they should be started before the temperature drops to freezing. It is easier to keep the fruit warm than it is to heat it up.

Fig. 1 shows one of these blowers as installed in a walnut orchard. It consists of a large propeller, airplane type, 12 ft in diameter, directly connected to a 425-hp engine, mounted on a platform 50 ft above the ground. This platform is geared to the engine and rotates about a vertical axis at a speed of about 15 revolutions per hour. Fig. 2 shows a smaller blower driven by a Ford V-8 engine and drawing air up through the central column, at the base of which is an oil furnace.

Different theories of why blowers prevent frost damage have been advanced, but, in my opinion, any protection is accomplished through the mixing of the cold air around the trees with the warmer air brought in by the blower. Be this as it may, of one thing we are quite sure, that whereas twenty years ago there were none of these in use, now there are over 150 in California, representing an investment of more than $400,000. There are at least four manufacturers building and selling them, and at the present time their popularity is increasing.

Several field studies have been conducted in an effort to determine the degree of protection provided by blowers and the limiting conditions under which they will work effectively. The majority of owners feel that these machines have been a sound investment. All agree that they have distinct mechanical and labor advantages over other systems of frost protection.

Due to radiation from the ground and objects on it,

Presented before the Power and Machinery Division at the annual meeting of the American Society of Agricultural Engineers, at Asilomar, Pacific Grove, Calif., June 28, 1938.

Author: Associate professor of agricultural engineering and associate agricultural engineer in the experiment station, University of California. Fellow A.S.A.E.

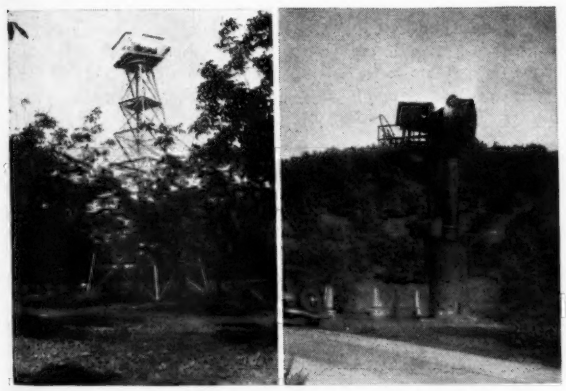


FIG. 1 (LEFT) A 425-HP BLOWER INSTALLED IN A WALNUT ORCHARD IN CALIFORNIA. FIG. 2 (RIGHT) A BLOWER DRIVEN BY A V-8 AUTO ENGINE FOR FROST PROTECTION IN A CITRUS ORCHARD. AN OIL FURNACE IN THE BASE DISCHARGES HOT AIR INTO THE FAN INTAKE

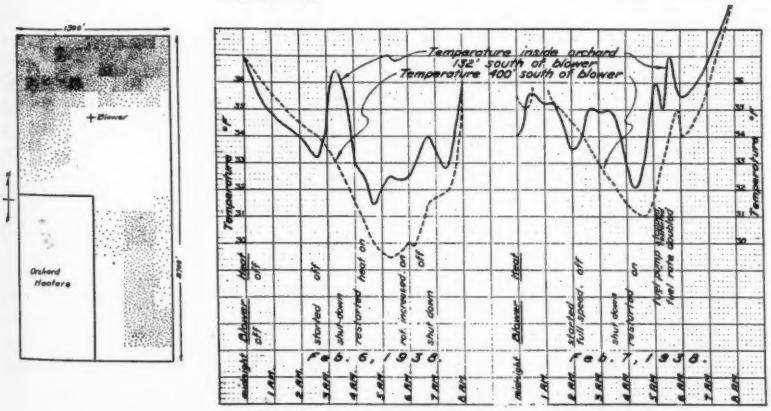
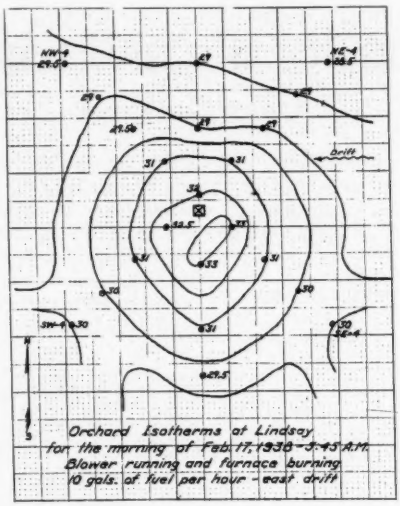


FIG. 3 (EXTREME LEFT) DIAGRAM OF WEBER'S ORCHARD SHOWING ESTIMATED FROST DAMAGE TO WALNUTS. SURVEY MADE APRIL 13, 1936. EACH DOT REPRESENTS 1 PER CENT. FIG. 4 (LEFT) RECORD OF TEMPERATURE IN AN ORCHARD EQUIPPED WITH A BLOWER AND SIMULTANEOUS TEMPERATURES OUTSIDE THE ORCHARD


Orchard Isotherms at Lindsay
for the morning of Feb. 17, 1936 - 3:45 A.M.
Blower running and furnace burning
10 gals. of fuel per hour - east drift

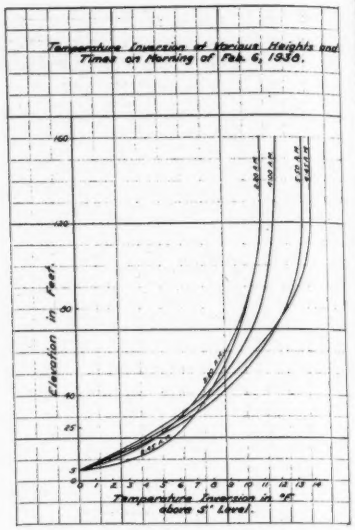

Temperature Inversion at Various Heights and Times on Morning of Feb. 6, 1936.
Elevation in Feet.
Temperature Inversion in °F above 5' Level.

FIG. 5 (RIGHT) ISOTHERMAL CHART OF TEMPERATURE INFLUENCE OF ONE BLOWER AND HEATER INSTALLATION. FIG. 6 (EXTREME RIGHT) AIR TEMPERATURES AT DIFFERENT ELEVATIONS AS TAKEN WITH ELECTRICAL THERMOMETERS ATTACHED TO A CAPTIVE BALLOON

the air under trees becomes cold, and a condition of "temperature inversion" is produced, that is, the air temperature increases with elevation and produces what is known as a "ceiling". On quiet nights this ceiling is generally low, while on windy nights it is high, or even may not exist. This leads us to believe, therefore, that there is a reservoir of indefinite depth upward of warm air, and if blowers can stir this air, it is reasonable to expect a warmer condition at the tree level. Whether this can keep up with the radiation is a question.

In the spring of 1936 temperature readings at various locations in a walnut orchard were taken. Temperatures at different elevations up to 66 ft above the ground were also obtained, and two weeks later an estimate of tree and fruit damage was made. The maximum rise in temperature within the orchard over that outside was not more than 3 deg; the maximum temperature inversion at the same time was less than 6 deg in 60 ft elevation; and the damage to buds that were on during the cold weather is shown in Fig. 3. Each dot represents 1 per cent damage.

It should be remarked here that there were several nights colder than those upon which observations were made. In the 20 acres north of the blower, there was a 43 per cent damage to the buds, and in the 10 acres southwest of the blower, 9 per cent while in the 10 acres southeast there was no damage. The prevailing wind during the season was from the northwest.

In the winter of 1934-35 two orange orchards, using a 10½-ft propeller driven by a 100-hp electric motor, and another with a 16-ft propeller driven by a 420-hp gasoline engine, were selected for observation. The fruit was picked from trees at different distances from the blowers, then taken to the packing house and graded into—sound (O), slight damage (S), moderate damage (M), total damage (B). Table 1 gives the results.

The relative score is obtained by giving a weight of 3 to O, 2 to S, 1 to M, and 0 to B. For example, the fruit between 90 and 100 ft on orchard A would score

$$(3\text{x}63) + (2\text{x}28) + (1\text{x}6) + (0\text{x}3)$$
$$\text{or } 189 + 56 + 6 + 0 = 251$$

The highest possible score is 300, and the lowest is 0. Recording thermometers in this area showed temperatures considerably below 32 F, some as low as 22 F for a short time. These data indicate positive protection.

The next year, because of the general mildness, we could get no helpful information.

This year, 1937-38, we have made observations of two different orange groves, one in the southern part of the state and one in the central. These were both equipped with blowers using a furnace in the base, in an attempt to blow heated air down over the trees. The propeller is about 25 ft above the ground, measures 67 in from tip to tip, and is direct connected to a Ford V-8 engine. Heat is provided by a furnace, at the base, capable of burning from 20 to 40 gal of oil per hour.

TABLE 1. ORANGES DAMAGED BY FROST (LINDSAY, 1934-35)

Orchard	Distance from blower, ft	O	S	M	B	R
A	90 — 100	63	28	6	3	251
	205 — 207	50	31	4	15	216
	322 —	24	12	16	48	112
B	300 — 400	73	21	2	4	263
	400 — 500	45	29	16	10	209
	500 — 600	6	37	32	25	124
	600 — 700	11	27	41	21	128

O = no injury; S = slight damage; M = medium damage; B = ruined; R = relative score.

Fig. 4 shows the effect of the blower upon a recording thermometer placed between the fifth and sixth tree rows south of the blower (approximately 132 ft). It may be noticed that the general trend of temperatures near the blower was to be above that outside, varying from 1.5 to 3 deg. Fig. 5 shows isotherms in the same orchard as obtained from minimum thermometers scattered through the orchard and read frequently during the night of February 17, when outside temperatures dropped as low as 29 F.

In order to obtain as much information as possible on the condition of the air above the orchard, thermometers were attached to a captive balloon and temperatures read up to an elevation of 160 ft. A plot of these observations is shown in Fig. 6. It may be of interest to note that temperature inversions, so far as our observations are concerned, amounted to as much as 11 deg in 66 ft at Farmington, even with a decided "drift", probably 5 mph; 11 deg at La Habra Heights, and from 8 to 13 deg in 160 ft at Lindsay.

It is my personal opinion that (1) under conditions of temperature inversions of 10 deg in 100 ft elevation, air temperatures in orchards may be maintained 3 deg higher, with a blower mounted on a tower 40 to 50 ft above the ground; (2) blowers of 75-hp size will not handle over 10 acres, excepting under conditions of favorable air drainage; and (3) it may be possible to effectively combine a blower with orchard heaters.

Engineering Service for Farm Users of Electricity

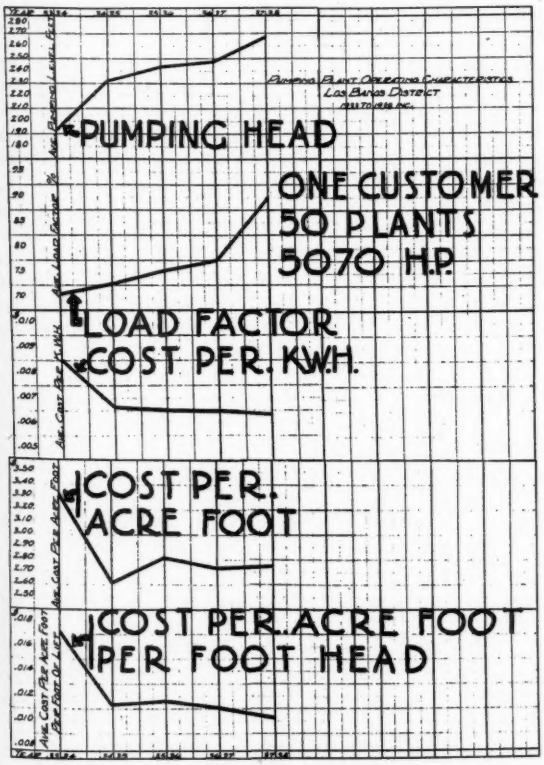
By E. G. Stahl

IT HAS been recognized for a long time that the volume of power required for agricultural purposes is large, and that much of this power could be economically supplied from central station service, but early experience proved that a great amount of effort had to be expended in developing equipment adaptable to farm use, and in selling the farmer on the value of electric service for his operations. Many farmers were willing to install and use electric lights and a few minor appliances, but in the less densely settled areas the use of these few appliances would not justify the cost of rendering the service. The job then was to develop electrical equipment for as many of the power requirements of the farm as possible, and to prove to the farmer the economical advantage of using this equipment.

In the 1937 Yearbook of the U. S. Department of Agriculture is found this statement: "The improvement of farm homes remains one of the unaccomplished tasks of agriculture. Observations in many parts of the country indicate that comparatively few farm families have yet found it practicable to provide themselves with modern homes, either through new construction or by modernizing the old dwellings."

Presented before the Rural Electric Division at the annual meeting of the American Society of Agricultural Engineers, at Asilomar, Pacific Grove, Calif., June 28, 1938.

Author: Agricultural engineer, San Joaquin Light and Power Corporation.



This fact, which in most cases results from the farmer's inability to supply better living facilities, is another major obstacle to the extension of electric service to farm homes, which is not generally recognized.

In contrast to the 19.3 per cent of all occupied farm homes receiving central station service, 28.7 per cent of all farm homes valued at $500 or more are receiving central station service. In my own company's territory there are many more farm homes to which service is available but which are not using service, than there are those which do not have the service available.

During the past two years the federal government, through the Rural Electrification Administration, has been giving some help to farmers desiring electric service, by financing farm cooperative lines. For the two-year period ending December 31, 1937, REA financed lines had brought service to approximately 33,000 farm homes. During the same period the private utilities had extended service to approximately 300,000 farm homes. I would suggest that closer cooperation between these two agencies would improve the results of both, and would be in the general public interest. Unquestionably the large volume of propaganda put out by REA has lessened sales resistance, which has materially benefited the private utilities in their rural service expansion program.

In the territory east of the one hundredth meridian, the average annual use of farm customers in 1937 was 1,014 kwh. In California and certain other western states the problem of rural electrification is of a somewhat different nature. The early adaptation of electric power to irrigation pumping in California has created a demand of such volume as to justify the construction of a distribution network that blankets practically the entire farmed area of the state. The average annual use of electric power for all farm purposes in the San Joaquin Valley in 1937 was 11,310 kwh per meter. The average domestic use amounted to 1,891 kwh, and the average power use for irrigation amounted to 22,050 kwh. This high annual use makes agricultural power a relatively large percentage of the total utility business, and therefore of great economic importance to the utility. To protect and promote this business in the interests of both the farmer and the utility, a number of engineering services have been set up by power companies.

Pump Testing Service. The San Joaquin Light & Power Corporation maintains three two-man pump testing crews which are kept busy throughout the year testing customers' pumping plants for the following major purposes:

1 To determine fulfillment of pump companies' guarantee provisions of customers' pump purchase agreements.

2 To determine the volume of water delivery in order that the farmer may decide upon crop acreage limitations, also as evidence of a water supply in securing crop loans.

3 To determine unfavorable operating conditions, from which recommendations are made for improving the operating efficiency of the equipment.

4 From the power company's standpoint, to determine basic cost information with which to meet internal-combustion engine competition.

This service has been maintained for fifteen years. A total of 11,377 tests had been made at the end of 1937.

The average cost per test was $7.41, including, in addition to the field work, all office work of preparing and delivering the customers' reports. The company makes no charge for these tests. This service has been of material assistance in reducing the farmers' cost for pumped irrigation water. The farmer, the pump dealer, and farm lending agencies all depend upon this service for operating information. In order to assure accurate results, an equipment testing laboratory is maintained in Fresno, where the field instruments can be calibrated under all operating conditions. With this equipment, calibrations can be checked simultaneously by orifice, by weir, and by volumetric measurement.

Field Engineering Service. In addition to the pump-testing service, our company maintains a crew of eighteen field engineers who are qualified to analyze the customers' irrigation problems and to recommend the type and size of equipment and the best method of use.

When it is considered that the 17,500 pumping plants served by the company range in size from 2 to 500 hp, that pumping heads vary from 5 to 500 ft, and that the annual period of operation extends from 2 to 52 weeks, it may be realized that these men have a variety of problems to solve. Not only do conditions vary in different parts of the territory, but they change from year to year within a given territory. The maintenance of the highest operating efficiency is of great importance to both the farmer and the company.

Agricultural pumping rates are set up on an annual basis with a sliding scale. Greater use per year therefore results in a lower average rate for power and a lower unit cost for pumped water. In recent years much has been accomplished for both the farmer and the company by encouraging the installation of smaller plants which will operate a greater number of hours per year to pump a given quantity of water. The result is lower investment for pumping equipment and for power facilities, lower cost to the farmer for water, and greater profit for the company by virtue of higher load factor and lower demand.

An outstanding result of what has been accomplished on large-scale farming operations is shown on Fig. 1. This customer, who at the present time is operating fifty pumping plants, totalling 5,070 hp, increased his average annual load factor from 72 per cent in 1934 to 90 per cent in 1937. One plant operated at 100 per cent load factor during the year 1937. In order to achieve results of this kind, it is necessary to secure the closest cooperation from the operators. With pumping bills running into thousands of dollars per year, this can usually be done.

For the larger customers our field engineers maintain a complete monthly record of each pumping plant. They consult regularly with the farm operator, advising him of the efficiency and use of each plant, and recommend changes necessary to secure the best results. From this record the farmer is able to determine at any time the efficiency of each plant. When his crop water requirements fall off, he is able to take out of service those plants which are the most costly to operate. Also, he can balance the cost for reconditioning against the saving that can be made, to determine whether the plant should be repaired. When the efficiency of a plant falls off to a point where it appears to be economical to have it reconditioned, the plant is tested and a comparison report submitted showing present water costs and the cost that can be effected by reconditioning (Fig. 2).

In order to secure greater interest and cooperation from the farm customers in bringing about these changes which result in greater use and lower water costs, it has been

SAN JOAQUIN LIGHT AND POWER CORPORATION
MIDLAND COUNTIES PUBLIC SERVICE CORPORATION

EFFICIENCY COMPARISON

NAME _____ DISTRICT Los Banos DATE 4/29/36 Index No. 1-0135

METER NUMBER 94329 TRANS. LOC. NO. _____

MOTOR Fairbanks-Morse H.P. 50 SERIAL NO. 132542

LAND LOCATION _____ SEC. _____ T. _____ S. R. _____ E.

OPERATING CONDITIONS AT PRESENT — Before Reconditioning		OPERATING CONDITIONS AT — After Reconditioning — OVERALL EFFICIENCY	
Gallons per Minute Pumped	369.00	Gallons per Minute Pumped	557.00
Total Pumping Head	222.49	Total Pumping Head	254.58
Horsepower Input to Motor	69.83	Horsepower Input to Motor	57.54
Kilowatt Input to Motor	52.09	Kilowatt Input to Motor	42.92
K.W.H. per Acre-foot Pumped	766.61	K.W.H. per Acre-foot Pumped	418.36
Plant Efficiency Overall	29.65%	Plant Efficiency Overall	62.16%
Cost per Kilowatt Hour	$.00651	Cost per Kilowatt Hour	$.00893
Cost per Acre-foot	$4.99	Cost per Acre-foot	$3.74
Yearly K.W.H. Consumption	356,880.00	Saving per Acre-foot	$1.25
Yearly Cost	$2325.96	Pumping 466 Acre-feet @ $	1597.34
Acre-feet Pumped	466.00	Saving per Year	$728.64
Hours Operated	6851.00	Per Cent of Saving	31.32%
		K.W.H. Consumption	194,965.00
		Hours Operation	

Operating same number of hours as last year an additional 237 Ac. Ft. can be pumped at a saving of $402.76 over last years bill.

San Joaquin Light and Power Corpn.
Sales Dept.

necessary to do considerable advertising and promotional work to acquaint the farmer with the benefits he could obtain. The most effective educational work was through a pump test exhibit, showing the causes of high water costs, the advantages of proper equipment, and the use of our pump testing and engineering service in securing best results. This exhibit has been shown at fairs, to high school agricultural classes, farm bureaus, etc. At each showing a large number of applications for testing service were received.

Through these various services which I have briefly described, a general acceptance of electric power for irrigation pumping has been built up which has enabled us to obtain and retain 95 per cent of all the irrigation pumping business within our territory, and to develop an average annual use of more than 22,000 kwh per irrigation meter.

System Agricultural Load Factor. Load factor, or per cent of capacity operation, is an important factor in any class of business and is of particular importance in the utility business. On our company's lines, the agricultural pumping load creates the system peak demand. This peak occurs during the last two weeks of July. During this period practically every pumping plant on the system is in operation. Generation, transmission, and distribution facilities must be provided to meet this peak demand and the investment charges on these facilities continue throughout the year, whether the demand continues for a short period or a long period. It is therefore obvious that if high use can be continued over a longer period of time, the unit cost of electric power will be lower and the benefits can be passed on to the customer in lower rates and to the company in increased profits.

Farm Efficiency Supported

WE CAN produce the sugars and the starches, the fibers and the fuels, that America needs. From the farm must come the paper, the paint, the plastics, the starches and the fats that our civilization requires. The farmer can efficiently produce all the food and fiber needed to feed and clothe the millions that live in America. We have only touched the possibilities in present production and in new methods and crops. Efficient production is the bed rock of rural progress.—*Louis J. Taber,* in an address before the Fourth Annual Farm Chemurgic Conference.

Grass Silage Harvesting Methods

By Frank H. Hamlin

HARVESTING, storing, and feeding uncured hay crops as silage offer the following important advantages over handling field-cured hay by conventional methods:

1 Delays and losses due to weather are largely eliminated. W. H. Peterson of the Wisconsin Agricultural Experiment Station says that in making dry hay from legumes under favorable conditions, about 25 per cent of the value of the crop is lost; under unfavorable conditions, the loss may exceed 50 per cent; whereas the feeding value of these crops is well preserved in properly made silage (1)[1].

2 The cost of providing a cubic foot of storage space in a hay mow and in a silo is about the same, but the average cubic foot of silo space will store over three times as much dry matter as the average cubic foot of mow space.

3 Silage is not subject to spontaneous combustion which, in stored hay, annually accounts for a fire loss in the United States of more than twenty million dollars (2).

4 A given amount of roughage dry matter can be fed with somewhat less time and labor in the form of silage than in the form of whole dry hay.

5 Considerably less dust and less feeding waste are associated with grass silage than with dry hay.

Investigations at a number of experiment stations and in the field during the past few years have shown that these advantages will usually offset the cost of the preservative used in grass silage making, with a substantial margin to spare. In this connection, it should be noted that when molasses is used as the preservative, the nutrients of the molasses are still largely available, though in a different form, after the ensiling process is completed, and molasses is a relatively cheap feed in many areas (3). Phosphoric acid treatment also pays its own way to a large extent by supplying much needed phosphorus to livestock rations of certain areas and by returning phosphorus to the soil via the manure route (4).

Paper presented before the North Atlantic Section of the American Society of Agricultural Engineers, at Toronto, Canada, October 12, 1937.

Author: Research engineer, Papec Machine Co. Mem. A.S.A.E.

[1]Numerals in parenthesis refer to papers listed at the end of this paper.

FIG. 1 MOWING AND WINDROWING IN ONE OPERATION

The principal objection to harvesting hay crops as silage has been the necessity of loading and hauling about 7500 lb of material to harvest one ton of dry matter, as compared with handling 2500 lb of material in harvesting a ton of dry matter in the form of field-cured hay. In other words, it is necessary to make three trips to the field where one was made before. Assuming that grass silage from a given acreage has 25 per cent greater feeding value than the same acreage of dry hay made under favorable conditions, the question is — how much more does it cost per ton of dry matter to move the crop from field to storage, and what can be done to reduce the cost of harvesting uncured hay crops on the ordinary farm. It is with these two questions that this discussion is primarily concerned.

Table 1 shows typical harvesting costs for putting 100 tons of field-cured hay into barn storage, using a five-man crew, and the following horse drawn equipment: A 5-ft mower, side-delivery rake, loader, two wagons, and double-harpoon fork or slings.

TABLE 1. TYPICAL COSTS OF HARVESTING 100 TONS OF HAY (5)

	Costs for 100 tons (80 tons dry matter)		Cost per ton of dry matter
Mowing (33 hr)			
1 man at 30 cents	$ 9.90		
2 horses at 10 cents	6.60		
Mower	7.00		
		$ 23.50	$0.29
Raking (20 hr)			
1 man at 30 cents	6.00		
2 horses at 10 cents	4.00		
Side rake	7.00		
		17.00	0.22
Loading and hauling ¼ mi (34 hr)			
3 men at 30 cents	30.60		
4 horses at 10 cents	13.60		
Loader and 2 wagons	11.00		
		55.20	0.69
Storing (34 hr)			
4 men at 30 cents	40.80		
2 horses at 10 cents	6.80		
Fork, rope, track	12.40		
		60.00	0.75
Totals		$155.70	$1.95
Summary			
Man-hours 291 at 30 cents	$ 87.30		$1.09
Horse-hours 310 at 10 cents	31.00		0.39
Equipment costs	37.40		0.47
Totals		$155.70	$1.95

In harvesting uncured hay crops, farmers have quite naturally proceeded along much the same lines as when putting up dry hay. The mowing operation is, of course, the same. Raking immediately follows mowing, but costs the same except that only one raking is required regardless of weather, whereas the crop may have to be turned several times for field curing under unfavorable weather conditions. Loading and hauling green hay with equipment designed for dry hay, however, cost nearly three times as much per acre harvested. The storage operation costs about the same per acre for silage as for dry hay (6). In other words, the whole harvesting operation for grass silage costs less than $3.50 per ton of dry matter stored, or around $1.50 more than the cost of harvesting a ton of dry matter in the form of field-cured hay.

This added cost per ton of dry matter may not seem excessive as long as it results in adding 25 per cent to the usefulness of the crop, which, with hay selling at $10 a ton, may be valued at about $3 per ton of dry matter. The net saving of about $1.50, however, is almost entirely wiped out by a charge of around $2.50 per ton of dry matter for the molasses or phosphoric acid treatment, of which at least half may be considered as added feed or fertilizer value and half as harvesting cost (7). It must also be recognized that while the nutrients of the growing crop are well preserved as grass silage, there are some losses during the fermenting process.

The use of conventional haying equipment and methods to make grass silage results, therefore, in practically no advantage over taking the 25 per cent loss that goes along with hay making under favorable conditions. In bad haying weather, however, the certainty of much more extensive losses would make ensiling the crop a substantially profitable operation. Furthermore, we have not as yet taken into consideration the costs of providing storage space for the crop, removing it from storage and getting it into the livestock. These are by no means minor items in the total cost of converting a growing hay crop into meat, milk, or wool.

Numerous feeding trials have shown that stock reject or otherwise waste from 5 to 30 per cent of all whole dry hay fed, depending on the quality of the hay and the feeding methods used (8). Properly made grass silage is eaten virtually without waste. Reports from farmers indicate that grass silage is removed from storage and fed with considerably less time and labor than whole dry hay. The cost of silo space for grass silage is less than $1.25 per ton of dry matter stored per season (9). The cost of mow space for whole dry hay exceeds $3.50 per ton of dry matter stored per season. This may mean nothing to the farmer who already has plenty of mow space and no silo, but it means much to the farmer who is up against new construction.

A number of more or less successful efforts have already been made to reduce grass silage harvesting costs. At least two types of combined mower-loaders were introduced during the past season. Both require 4-man field crews—one man on the tractor which draws the combine, two more to build the load, and a fourth to drive the wagon or truck which moves alongside the combine. These machines provide somewhat more freedom from stones in the loads, which lengthens the life of ensilage cutter knives, but they do not appreciably reduce the man-hours required to harvest a given acreage, reduce the size of the crew required, speed up the operation, nor decrease equipment expense.

Various types of field choppers have also been tried. These machines generally pick up the crop after it has been windrowed and deliver it in chopped form to wagon box or truck. They permit hauling somewhat larger loads and make loading and unloading less arduous although not much faster. The objections are that labor costs have not been appreciably reduced and that relatively large operations are necessary to justify the equipment expense. A heavy tractor or a light tractor with separate power unit to drive the chopper is necessary in the field, plus a power unit and blower at the silo.

While special harvesting equipment may offer worthwhile savings for large operators, minor changes in ordinary equipment and crew management seem to offer greater possibilities for the average farmer. A $10 to $20 windrower attachment for any horse-drawn or tractor mower eliminates the raking operation and most of the stone problem. By replacing rope with chain and strengthening slats, cylinder loaders can be made to handle heavy green crops satisfactorily. Heavy duty, cylinder-rake bar loaders, designed for handling green as well as dry hay, are now available at only a few dollars more cost than standard loaders.

The use of a truck materially reduces hauling time. Dump bodies may be inexpensively built for trucks, trailers or wagons. Slings, V-ropes or other devices may be used to roll or slide the loads from wagon or trucks. With the wheels of the silo filler set in the ground to the axles, the labor of feeding the machine is reduced. Pitching with both feet on solid ground is easier than from the top of a load, and any stones in the load are more apt to be observed.

Table 2 shows how these expedients are being used to lower grass silage harvesting costs on one New York state farm. One man takes care of the mowing and windrowing at a cost of 30 cents per ton of dry matter as compared with a minimum of 51 cents per ton of dry matter for mowing and raking the crop in dry hay making (Fig. 1).

A second man does all the loading and hauling at the rate of one 2500-lb load every eight minutes. Because the uncured crop is heavy, the truck driver is usually able to put on loads of this size without leaving his cab and with no one on the load. The heavy-duty loader simply dumps the green hay onto an 8x12-ft bed. An occasional quick stop throws the peak of the load forward on the truck. (Fig. 2).

The third and fourth members of the crew, stationed at the silo, feed the dumped loads through the chopper in five to seven minutes, which leaves time for one of the men to take care of the preservative supply and the other to level off in the silo, although in practice a boy is usually assigned to the latter job (Fig. 3).

FIG. 2 ONE MAN, UNASSISTED, LOADS AND HAULS 2500 LB OF GREEN MATERIAL TO THE SILO EVERY EIGHT MINUTES

FIG. 3 TWO MEN PUT A LOAD THROUGH THE CHOPPER IN FIVE TO SEVEN MINUTES

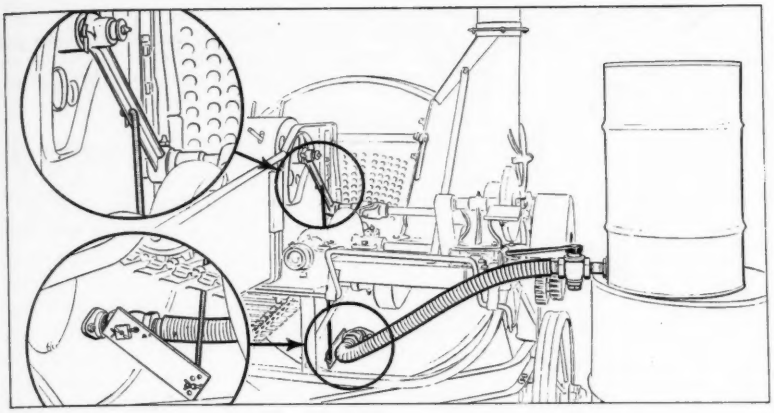


FIG. 4 AUTOMATIC PRESERVATIVE DISTRIBUTOR APPLIES MOLASSES OR PHOSPHORIC ACID IN PROPORTION TO THE VOLUME OF FORAGE PASSING BETWEEN THE FEED ROLLS OF THE CHOPPER

TABLE 2. COSTS OF HARVESTING 300 TONS OF GRASS SILAGE

	Costs for 300 tons (80 tons dry matter)		Cost per ton of dry matter
Mowing and windrowing (33 hr)			
1 man at 30 cents	$ 9.90		
2 horses at 10 cents	6.60		
Mower and windrower	8.00		
		$ 24.50	$0.30
Loading and hauling, ¼ mi			
1 man, 32 hr at 30 cents	9.60		
Truck, 150 ton-mi at 6 cents	9.00		
Heavy-duty loader	18.00		
		36.60	0.46
Storing (32 hr)			
3 men at 30 cents	28.80		
Tractor (belt work) at 40 cents	12.80		
Chopper at 65 cents	20.80		
		62.40	0.78
Totals		$123.50	$1.54
Summary			
Man-hours 161 at 30 cents	$ 48.30		$0.60
Horse-hours 66 at 10 cents	6.60		0.08
Equipment costs	68.60		0.86
Totals		$123.50	$1.54

A comparison of the summaries of Tables 1 and 2 will show that under this system man and horse-hours are reduced and equipment costs increased with a net saving of 41 cents per ton of dry matter. Charge grass silage with $2.50 per ton of dry matter for preservative, less a 50 per cent credit for feed or fertilizer value, and we have an increase in total harvesting costs of 84 cents per ton of dry matter in return for which the farmer gets about three dollars' worth of nutrients ordinarily lost in hay making, a large potential reduction in storage space costs, a saving in the time and labor required to remove the feed from storage, and a virtual elimination of feeding waste.

During the coming season, the operator of the farm from which these figures were drawn expects to further reduce his grass silage harvesting costs by eliminating the separate mowing operation. His truck has been equipped with a power-take-off-driven mower bar, thus permitting one man to take care of the entire mowing, loading and hauling operation. Other farmers, whose layouts permit, are planning on the use of buck rakes to reduce transport expense.

Farm labor is becoming increasingly hard to obtain. According to a survey made on 100 farms in 1932 (6), 5.29 men are used on the average farm to load, haul, and store field-cured hay at an average rate of 2.34 tons per hour. The smallest crew used was three men. Because hay must be stored quickly to avoid weather damage and because three men are needed to operate a horse fork, probably no further reduction in crew size is practical. In harvesting grass silage with the equipment outlined above, it is possible to handle the job with a two or even a one-man crew because each operation involved can be performed with at least fair efficiency by one man.

During the past season one New York state farmer, assisted only by his 12-year-old son, who operated the mower and windrower, harvested his alfalfa as silage at the rate of about 20 tons per day. His equipment consisted of a loader, a tractor-drawn trailer and an ensilage cutter powered by an old car motor. Man-hours per ton harvested on this farm did not greatly exceed those of the highly efficient operation covered by Table 2.

No discussion of grass silage costs is complete without consideration of the methods used in applying the necessary preservatives. The simplest method consists of running the liquid by gravity onto the forage just before it goes to the feed rolls of the chopper. The objections to this method are that heavy containers must be elevated to a platform; when the chopper's apron runs empty, molasses builds on chain and sprockets, and acid is wasted; no very accurate check can be made on the amount of preservative being applied.

A more satisfactory method is shown in Fig. 4. A short hose leads from a measuring tank to a valve set in the lower part of the blower inside the periphery of the fan blades. A rod connects the upper feed rolls of the chopper with the valve (11). Enough acid or molasses to treat a load of forage is poured or allowed to run into the tank and a pail of water is added if desired to improve distribution of acid or to make molasses flow more freely. As the load is fed through the chopper, the rise and fall of the upper feed rolls open and close the valve, thereby controlling the volume of preservative applied in proportion to the volume of forage passing between the feed rolls. A second valve at the outlet of the tank controls the maximum opening of the supply line. This device eliminates heavy lifting, insures proper treatment of each load, prevents waste of preservative, and does away with clogging due to flow of the preservative when no forage is being fed through the chopper.

With improved harvesting methods, grass silage may be expected to replace field-cured hay on livestock farms with increasing rapidity. There are also a number of reasons why corn for silage may have to give way before green

hay crops. Heavy yields of green hay crops can be grown in many territories where corn does poorly. Grasses and legumes are soil conserving while corn is soil depleting. Heavy expense for plowing and cultivating must be charged against corn. Furthermore, these operations cause serious labor peaks on many farms (12).

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Stalls for Experimental Lamb Feeding

By Dr. T. B. Keith and J. E. Nicholas

A MEASURE of the exact quantity of feed consumed and feed refused by experimental animals used in nutrition studies require individual stalls constructed to restrict the feed consumption of the experimental subjects to the feed offered. The individual feeding stalls shown in the accompanying illustrations have been designed for convenience in handling animals and feed.

Individual stalls for feeding experimental lambs should be designed for convenience in feeding roughages and concentrates separately or in combination. They should be so constructed that each experimental lamb will not have access to unallotted feed. Each lamb should be able to see the other animals of the experiment at all times. The crate should be designed for moving without destruction. A three-stall unit is the most convenient size for moving and storage.

A photograph of the three-stall unit intact is shown in Fig. 1; the details of the construction are shown in Fig. 2. The feeder is a combination hay rack and grain trough, with the hay rack above the grain trough. The feeder is made in one section. The three gates and the gate holder are made in one section. The stall partitions connect the feeder to the gate holder. The stall partitions are attached to the gate holder with hooks and eyes. The dovetail attachment of the stall partition to the feeder and the gate holder with the hooks and eyes hold the three-stall unit in position. A bill of material for this unit follows:

Feeder	Number of pieces	Size
Front, V	3	1"x5¼"x4'-8" (tongued and grooved)
Side, B	6	1"x5¼"x3'-7¼" (" " ")
Studding, C	4	2"x4"x3'-0"
Frames, D	6	1"x3"x1'-7"
Frames, E	6	1"x2"x2'-2"
Bottom hay, F	1	1"x11"x4'-4½"
Front grain, G	1	1"x6½"x4'-4½"
Trough, H	1	1"x4"x4'-4½"
Bottom grain, I	1	1"x8"x4'-4½"
Partition, J	4	1"x10½"x2'-4½"
Partition, K	4	1"x1'-5"x1'-8¾"x9½"
Rail, A	1	1'x2½"x4'-4½"
Four partitions		
L	14	½"x3"x2'-6"
M	12	1" or ½"x3"x3'-¾"
N	4	½"x3"x4'-3"
Entrance grates		
Top and bottom, O	2	1"x4"x4'-8"
sides, P	4	1"x4"x4'-10"
Q	12	1"x1"x4'-10"
R	12	¾"x3"x1'-4"
S	6	¾"x3"x2'-6"
T	1	¾"x1½"x4'-8"
Corner braces (triangle) U	2	1"x8½"x8½"x12½"
V	7	3" hook and eyes

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Authors: Asst. prof. of animal husbandry and prof. of agricultural engineering (Mem. A.S.A.E.), respectively, Pennsylvania State College.

Author's Note: Credit is due Dr. W. L. Henning, associate prof. of animal husbandry (sheep) for many suggestions in the construction of the stalls.

FIG. 1 A VIEW OF THE THREE-STALL, LAMB-FEEDING UNIT

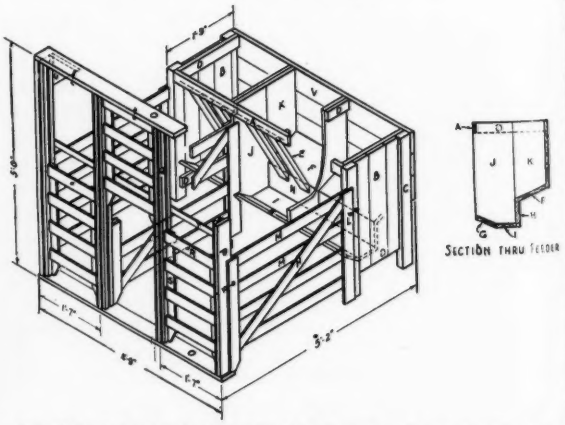

FIG. 2 DETAILS OF CONSTRUCTION OF THE LAMB-FEEDING UNIT

Spring Trip Cultivator Shanks

By A. W. Clyde

WHEN working in ground where stones or roots are encountered, a cultivator shovel needs overload protection. Twelve years ago, in starting to use tractor cultivators, the Pennsylvania Agricultural Experiment Station used the common type of spring trip shank, similar to Fig. 1. This caused annoyance and loss of time because it would seldom return to working position without help after being tripped. Spring teeth with 2 leaves, each ¼ x 1¾ in, were then tried. They were fairly satisfactory except that they tend to shrink away from hard going and their side flexibility often permits them to dodge a well-rooted weed. These difficulties prompted attempts to develop a better type of spring trip.

The inherent defect of the common spring trip is the location of the pivot point O in Fig. 1, in relation to the shovel point. When the device trips, the shovel tries to go deeper instead of shallower. This has two undesirable effects: High stresses are caused because either weight or spring force is holding the gang down; and the shovel is not likely to return to working position without help because it must either go very deep or must lift the gang of which it is a part. Calculation will show that an extremely large spring is needed to store enough potential energy to return the shovel if the average resistance to returning is high.

Fig. 2 is one developed by the author. It has been tested quite thoroughly in the field and has never failed to return to working position after being tripped. Fig. 3 is an Allis-Chalmers design which the author has tested, and for which a change in linkage has been suggested. The change is a relocation of pivot O to give the "fade-away" mentioned later. Another change recommended is a reduction of spring rate from 990 to 800 lb per inch. Both changes are incorporated in Figs. 5 and 7.

In studying the requirements of an improved trip, it was evident that pivot O must be vertically above the point of the shovel or possibly a little ahead of it. This is necessary to keep the average returning resistance within the capacity of a spring of reasonable size. Attention was then directed to the linkage connecting the shovel with the spring, and to what it should do. In discussing this the following symbols will be used:

S = spring force, lb.

H = horizontal force on shovel point to balance S alone, friction neglected, lb (computed).

H' = horizontal force at point needed to move shovel backward slowly, lb (determined by test).

H'' = horizontal force at point needed to hold shovel when returning slowly, lb (determined by test).

F = force at point due to friction, lb. It is a measure of friction of motion in all positions except at the start of tripping, when it measures friction of rest.

From the above it will be seen that for any certain position

$$H' = H + F, \qquad H'' = H - F, \qquad \text{and } F = \frac{H' - H''}{2}$$

It is realized that in practice the force on the shovel may not always be located on the point, also that the force may be in directions other than horizontal. The actual direction probably depends upon the shape of the obstruction and upon inertia effects which are difficult to determine exactly. A horizontal direction was chosen for comparative purposes because it is believed it may approximate many conditions encountered. It is also realized that the beam to which the shank is attached may have some vertical movement, as well as horizontal movement. Here, again, complicated inertia effects are involved. For simple comparative purposes it was thought advisable to disregard vertical movement of pivot point O.

The main function of the linkage is to modify the characteristic of the spring; namely, that S increases in proportion to the deflection. This is just the opposite of what is desired for H'; that is H' should preferably be large at the start of breaking and diminish as the shovel moves back. This quality is called the "fade-away". Friction is useful in assisting to increase H', at the start of tripping, but at all other times it is a detriment because it adds to the work which the spring must do on return. As might be expected, friction is a large item in these devices since few, if any, of the joints are lubricated. In the Fig. 2 style, all joints were tested dry, while in the Fig. 3 style, only the main pivot O was greased. Average values of F in motion for the two styles with the joints free are about 50 and 45 lb, respectively. The preload on the spring should be as low as practicable because the spring capacity represented by the preload is not available for returning the shovel. When the shovel is returning to working position, it encounters a varying soil resistance. The average resistance multiplied by the distance constitutes a certain amount of work done on the soil. Obviously the spring must have enough available capacity to do this work on the soil plus the work of friction.

Desired qualities, in addition to the common ones of reliability, reasonable cost, etc., may be summed up as follows:

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Author: Professor of agricultural engineering. The Pennsylvania State College. Fellow A.S.A.E.

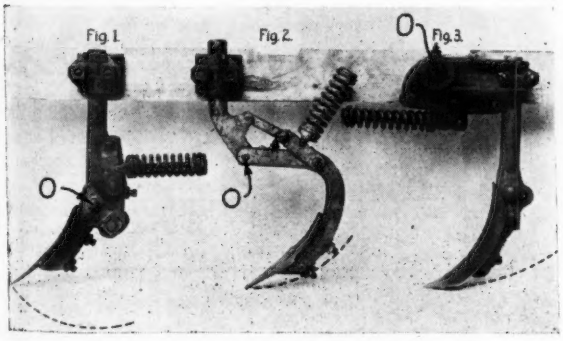


FIG. 1 COMMON CULTIVATOR SHOVEL SPRING TRIP. FIG 2 PENN STATE SPRING TRIP. FIG. 3 COMMERCIAL SPRING TRIP FOR WHICH A CHANGE IN LINKAGE HAS BEEN SUGGESTED

1 H' should be large enough at the start of tripping to hold the shovel rigid until an obstruction is struck. It should decrease as the shovel moves back, particularly near the end of travel.

2 H'' should be large enough to return the shovel under all ordinary conditions. Its average value must slightly exceed the average soil resistance encountered by the shovel on return.

3 Yielding to either side as well as in a backward direction should be provided.

The first two of these have been realized fairly well, but so far no practicable method of meeting the third is evident.

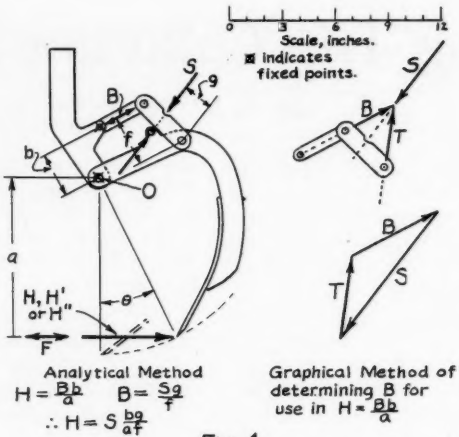


Fig. 4.

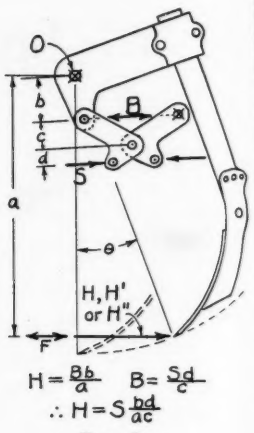


Fig. 5.

One of the first steps in the design of Fig. 2 was to determine the characteristics of several common styles of trips. The linkage of each was drawn in five or six positions and the spring deflection measured in each position. This, with a known spring rate and preload, gave a value of S which was used for computing the value of H for each position. Analytical or graphical methods similar to those shown in Figs. 4 and 5 were used according to which seemed most suitable. A trial layout of linkage was then made for the new design and was modified until it gave fairly satisfactory values of H. Two designs, like Fig. 2, which appeared most promising, were constructed and given laboratory tests by pulling on the shovel point. This gave values of H', H'', and F for the five or six selected positions. The final step was field testing to check up on the amount of spring preload needed and their general performance in actual work.

Comparison of Figs. 6 and 7 shows that the Allis-Chalmers design, with the changes suggested by the author, has better "fade-away" characteristics than the Penn State design. A drawback of the former in its present stage of development is its weight, 23½ lb without clamp and shovel. It may be possible, however, to lighten it to some extent. The Penn State design, which weighs 10½ lb without clamp and shovel, has shown no evidence of weakness with 5-in spearhead shovels in rather hard ground. It has not yet been tried with 10-in sweeps since sweeps of this size are seldom used in the Northeastern States. The principal objection made to the Penn State design is that the shovel is behind the shank instead of in front of it. This may interfere with using it on some existing cultivators, but does not seem to be an insurmountable difficulty.

In most devices, like the style shown, the adjustment for the breaking force (force required to start tripping) is rather sensitive. Distance c in Fig. 5 and the corresponding distance in Fig. 4 is about ¼ in when the mechanism is in working position. A small decrease in this distance will increase the breaking force considerably. Paint or rust in the joints, or joints riveted tightly have a similar effect, and also increase the friction in all positions. These features, however, are not peculiar to the new designs; they have been present since the beginning of spring trips.

It is believed that the two designs represent a real improvement in spring trips. At least they show there is good prospect of eliminating the inherent defect which practically all such devices have had in the past. Probably continued study will result in further improvements. An almost unlimited variety of linkages can be investigated and probably arrangements can be devised for improved styles which will interchange with any present style.

FIGS. 6 AND 7 CHARACTERISTICS OF THE TWO IMPROVED TYPES OF SPRING TRIPS WHEN ADJUSTED FOR SATISFACTORY OPERATION WITH 5-IN SPEARHEAD SHOVELS IN FAIRLY HEAVY SOIL

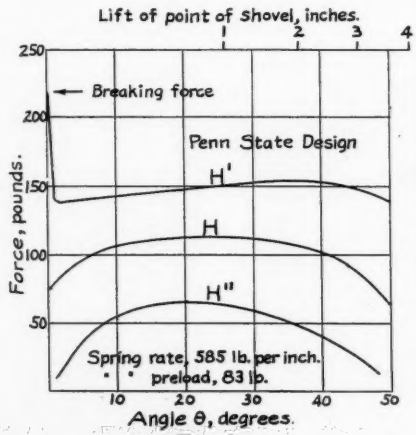


Fig. 6.

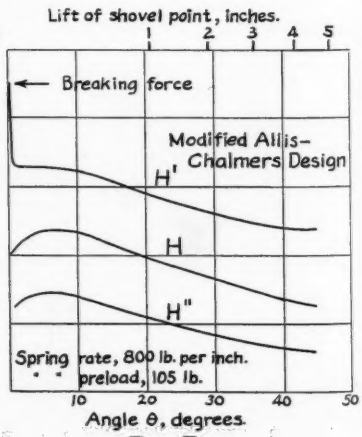


Fig. 7.

Relation of Soils to Mechanical Erosion Control Structures

By O. R. Zeasman

THIS PAPER covers some field observations made during fifteen years of extension work in soil erosion control. The work was confined to one state, Wisconsin, and largely to one part of that state, but other states have related or parallel conditions to which these observations may have application.

In order to be on common ground we need to limit the field by a few definitions, both as to the kind of gullies on which we use mechanical control and the types of structures to be used.

The term gully is being used indiscriminately to mean any ditch that is the product of erosion. It may range in size from a few feet in depth and width, carrying runoff from a fraction of an acre, to the mammoth gully over 100 feet wide and deep, carrying the runoff from one hundred or more acres. For our discussion let us divide gullies arbitrarily into two classes on the basis of treatments required for control. Place in the first those gullies that result from advanced sheet erosion and call them shoestring gullies. No discussion of control of this type of gully is included in this paper.

This discussion is limited to gullies of the second class, that carry runoff from watersheds of 15 to 20 acres or larger and that have a vertical overfall of at least several feet, commonly 25 to 30 ft or more, at the lip. These can logically be called outlet gullies.

Mechanical erosion control structures considered are those constructed of durable material, such as reinforced concrete and masonry, and designed to last for at least a generation. The relation of soils to such structures can be discussed from three viewpoints: (1) Condition or characteristics of soils and subsoils that limit effective control methods to permanent structures; (2) subsoil conditions of the subgrade and of the outlet channel below the structure, and character of the fill material that must be considered to insure reasonable permanence in the structure, and (3) the soil quality, which must be good enough and the protected land have high enough value for permanent crop production, to secure benefits great enough to justify the cost.

It is not feasible to classify soils for these purposes after the method used by the soil surveyor, but rather broadly on basis of origin, especially of the deeper subsoil, as to characteristics that make a particular group of soils especially erodible. Within such classification we include three kinds of soils—stream terrace formations, lake beds, and loess soils.

Briefly, these three groups of soils, due largely to their method of formation, are of such character that mechanical control methods are necessary to control outlet gullies that receive the runoff from considerable areas. The high overfall, characteristic great depth, flat grade of the bottom, absence of boulders or other coarse material that might serve as pavement for the bottom of the gully, all add to difficulties of control by any method except permanent structures with medium to high heads, depending upon depth of gully and surrounding topography.

Presented before the Soil and Water Conservation Division at the fall meeting of the American Society of Agricultural Engineers at Chicago, Ill., December 2, 1938. (NOTE: This paper appears here in condensed form. The parts omitted deal largely with the geology of highly erodible soils. Mimeograph copies of the original may be obtained by A.S.A.E. members on request to Society headquarters.)

Author: Extension agricultural engineer, University of Wisconsin.

SOIL REQUIREMENTS FOR FOUNDATIONS AND FILLS

All gully control structures are built on foundations of soil, subsoil, or bedrock, and most of them require earth fills. In structures with low heads possible repairs are not expensive, and foundation and fill requirements need not be exacting. But in structures with high heads like the drop inlets, earth foundations under the barrels and fill materials are important considerations in permanence and to secure freedom from necessary repairs.

Prior to 1933, we had helped farmers build several dozen of these with heads up to 25 ft. The foundations for these ranged from silty clay loam to coarse gravelly sand. Fill materials ranged from loess subsoil (light-colored silt loam) to medium sand. On these dams there were no foundation failures and only one fill failure. That was due to lack of tamping along the barrel. Repairs were made by tamping sandy loam soil beside the barrel and replacing the balance with teams and scrapers as in the original fill. That was in 1930 and the structure has given no trouble since. I believe the uniformly good results obtained with these early structures can be attributed to making the fills in easy stages. Common practice was to build about 10 ft the first year, followed by about 4-ft layers each succeeding year. This allows time for wetting, weathering, and gradual adjustment, which prevents dangerous settlement cracks such as are likely to occur in high fills built in a short time. These favorable results were an advantage of method of construction rather than ideal selection of fill materials, because any readily available soil was used. I might add in passing that nearly all these fills had slopes of about 1 to 1.

Since the summer of 1933, CCC camps have constructed some 500 drop-inlet dams with heads from 10 to 40 ft, and about an equal number of other types with lower heads. These drop inlets were built on all types of foundations and with a wide range of fill materials. Slopes were 2 to 1 for heads up to 30 ft, and 2½ to 1 for higher heads. Failures resulting in total loss of structures have been less than 1 per cent, and partial failures of fills less than 15 per cent of the entire number built.

The total failures were due to soil conditions of the foundations. Brief descriptions of conditions where these failures occurred are as follows:

1 Glauconite shale and sandstone disintegrated to a very soft gravel. This material was water-bearing to the extent that springs broke out in the excavation for the barrel. The springs were drained by a line of tile beneath the lower two-thirds of the barrel. They were laid in the sandstone fragments, bedded in gravel at the sides, with the upper part left exposed. The concrete for the barrel was poured directly on the exposed top of the tile and served to hold them firmly in position. The outlet of the tile dis-

charged through the concrete toe wall. This structure failed with the first heavy rain, by undermining. Whether this was due only to the coarse soft material of the foundation, or whether the drain was a contributing factor, cannot be determined. However, as the barrel tilted out of position, the tile remained intact as an integral part of the barrel, and it did not appear that the openings of the joints in the tile line were large enough to permit fill material to escape into them through the gravel filter. Therefore, it seems logical to attribute the failure to the foundation of friable sandstone and shale fragments.

2 Another failure occurred where the foundation was very much weathered sandstone, in which some layers were disintegrated into sand and other layers remained as large slabs of soft sandstone. This failure did not occur until after two years of service. It appears to have been caused by the formation of seepage channels through the layers of coarse sand between the sandstone slabs.

3 A couple of foundation failures occurred where water-bearing fine sand was encountered. These failures can logically be attributed to difficulty of securing good, safe construction when foundations are wet, because no trouble resulted on other wet foundations where the soil was the same. Then, too, many other dams were built on similar soil when dry, but which must have become water-bearing after the dams were in service and the ponds filled with water. Wet foundations ought to be avoided wherever possible because of construction hazards and additional cost. From the viewpoint of soils, mere general wetness of apparently homogeneous material need not rule it out as unsafe foundation. Soft sandstone fragments with pore spaces between large enough to cause springs, ought not be considered suitable foundation.

From a positive viewpoint, a summary statement would be that the balance of the 500 structures, built on a wide range of subsoil materials from impervious lake clays to coarse sand and gravel, developed no foundation failures.

When structures are built on limestone foundations or limestone covered with a layer of soil, good judgment must be exercised to avoid location of the structures on sinks. We have had three of these break out under ponds formed above dams but have been able to plug them with concrete at small expense. Had we been unfortunate enough to place the barrels over these critical points, failure of the structures would have resulted.

We have built several dams on sites where a layer of peat was encountered in the gully banks. A trench 6 ft wide was dug through the peat bed and a core of regular fill material placed in it with satisfactory results.

A few failures of clay fills have occurred in the spring of the year just as the frost was leaving the ground. These were probably due to expansion of saturated clay upon freezing and then forming a shrink crack as the frost left in the spring. This danger could be reduced by covering the outlet in the fall to reduce freezing. Prevention would be to use only sandy loam or fine to medium sand soil as fill for 3 ft next to the barrel. These materials have enough lower moisture content to have less expansion and contraction with freezing and thawing.

A common conception of fill material is that clay to silt loam is most desirable, because of apparent imperviousness. This may be true for fills where the water is kept at a nearly constant head and the fill is kept uniformly wet. But where subjected to alternate wetting and drying, such soils have some characteristics undesirable in fill material. The high content of colloid and clay cause expansion and shrinkage with changes in moisture content. Maximum density of these soils is at about 12 to 15 per cent moisture, with less density at both lower and higher moisture. A field laboratory to check this requirement when placing the fill, would be desirable but not always practicable. A rough test is helpful. Take a handful of the soil and squeeze it into a lump by closing the hand. If it has moisture enough to keep its shape well as a ball, but not enough to appear shiny or plastic, it is safe to use in the fill. This is about the same moisture content required to produce good tilth in a silt loam when cultivating.

We had our saddest experience with fill failures in silt loam fills in the late fall of 1933. These fills were put in during the drought of late summer and fall, with the result that fill material was too dry. With the advent of rains and wetting of the fills, shrink cracks developed and caused leaks in the fills.

A surface soil high in organic matter, like a prairie soil, reacts to changing water content like the high-colloid clay soil. Avoid putting this into the body of the fill, but it may be used to face the downstream slope. In the upper part of the Cambrian sandstone we often find layers of glauconite shale. Soils derived from this material have a soapy feel, are unstable when wet, and not suitable for fill except in a mixture with sand. This is a common characteristic of soils derived from shale.

One drop inlet dam about 25 ft high started hurriedly in the early days of the CCC camps was composed of coarse sand and gravel because no better fill material was available at site of the dam. When this pond filled with water, the fill leaked so badly that regular springs formed at its base, threatening failure. We saved the fill by cutting a port into the river about 6 ft above the barrel. The upstream surface of the fill was faced with about one foot of silt loam. This stopped the leakage completely.

With the exceptions noted above, we have made fills of all other materials encountered. This makes it seem that failures are not primarily due to inherent weakness in the materials, but more to method of placing the fill. This involves proper moisture content, thorough tamping next to the barrel and at contact to the bank, placing in layers and preferably extended over several seasons to permit weathering and adjustment. The kind of fill least affected by moisture conditions and embodying ideal combination of stability and imperviousness would be about as follows. Use about 3 ft of sandy loam or fine to medium sand for tamping and at the top of the barrel. Use gravel for the downstream fourth of the fill for stability and to secure drainage, follow this with sand grading from coarse to fine for the next fourth, and finish the upstream half with sandy loam.

The outlet below a drop-inlet dam offers a complex problem. Quantity of discharge, length, width, and gradient of the gully below the dam, coarseness of soil, stability of the gully banks, present and probable future ability of the soil to grow a dense cover, and kind of sediment that will come through the dam after its storage space is filled, all enter into our consideration of the grade that will be stable below the dam. A silt loam subsoil barren of vegetation will require a slope as flat as 0.5 per cent, while gravel appears safe up to 2 per cent. We have one gravelly channel over 1000 ft long with a 2 per cent grade that has shown no perceptible change in the last eight years since the structure, draining 230 acres, was built at its head. No material amount of vegetative cover is growing or is likely to grow on it. My opinion used to be that other sands would grade in fairly uniform scale between these extremes, but I question that opinion now. This should be true on the basis of *(Continued on page 324)*

Pumping Equipment for Irrigation

By Ivan D. Wood

THE RECORDS of the first efforts of man to construct devices for raising water from wells or streams to an elevation from which it would flow to growing crops, are lost in antiquity. One early step in the development of the pump consisted of a large, crudely made wheel with bucket-like containers attached near the rim. When driven by the force of the stream in which the lower edge was immersed, or by animal power, each bucket filled as it dipped beneath the surface and with its contents was elevated to a height equal to the diameter of the wheel where it was upset, upon striking a projection, pouring the water into a flume. Many variations of this principle were developed, some of which have come down to the present day. The Archimedean screw, consisting of a long auger rotating in a sloping tube, was probably the forerunner of the modern axial-flow pump. The former, however, was operated at a very low rate of speed by manpower instead of an electric motor. Other early devices were the endless chain carrying a series of buckets, the water shovel, and a lifting lever.

Pumps Used in Modern Irrigation Practice. Modern pumps are best classified according to the principles of their design and construction. Those types which are of special interest in irrigation are, in order of their importance, the centrifugal which strictly speaking includes the vertical turbine, the propeller, the reciprocating, the rotary, and the air lift. The discussion of the last three types necessarily must be brief since they have little importance in the irrigation field at present.

Presented before a joint session of the Power and Machinery, Soil and Water Conservation, and Rural Electric Divisions at the fall meeting of the American Society of Agricultural Engineers, at Chicago, Ill., December 1, 1937.

Author: Extension agricultural engineer, University of Nebraska. Mem. A.S.A.E.

The small, single-acting plunger or reciprocating pump, so widely used to furnish the farmstead water supply and, to a limited extent for garden irrigation, is familiar to all. When made in large sizes, the first cost is high and because of its relatively low speed, is incapable of furnishing a flow much in excess of 50 gpm (gallons per minute), but when used in conjunction with small earth reservoirs, or supply tanks, it has some application for watering large gardens, vineyards, and fruit trees. Many types of double-acting, reciprocating pumps are manufactured with capacities up to 600 gpm. They are, however, seldom used in raising water for irrigation, except where the lift is excessive and the crops to be watered are high priced.

In the rotary pump two cams or gears are meshed together and rotate in opposite directions. The case surrounding the gears fits closely at the sides and ends of the teeth. The liquid being pumped is carried by the gear teeth from the suction to the discharge side of the case. At one time, large capacity rotaries were used to some extent in irrigation practice. They have, however, fallen into disuse due to slow-speed operation, large size of case, and tendency to lose efficiency where the water being pumped carries sand or grit. Both the reciprocating and the rotary pumps are of the positive discharge type with a definite displacement of liquid at each stroke or revolution. Each may be used for exceedingly high lifts of 200 feet or more.

The air lift depends for its action on the release of compressed air, near the bottom of a pipe extending a considerable depth below the water surface. The air bubbles in the water column expand, reducing its weight and causing an upward flow. The efficiency of the system is usually low, but it has the advantage of being able to produce greater discharges from small-sized walls than is possible by other means. The first cost is ordinarily high and its use limited to wells having a water depth which is always at least twice the lift.

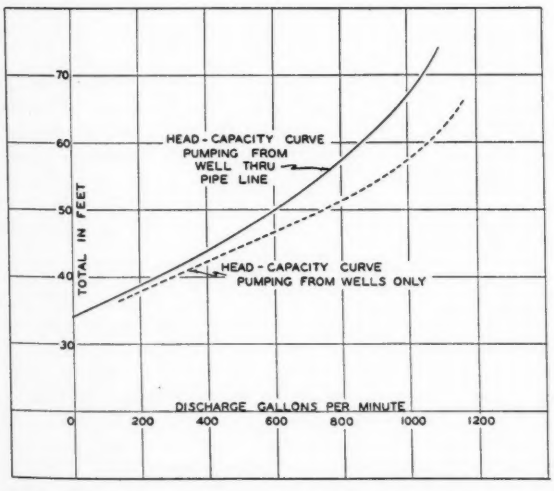


Fig. 1 When pumping from wells, a head-capacity curve as shown by the dotted line is obtained due to drawdown of the water level. The head-capacity curve shown by the solid line results when pumping from same well through a 6-in diameter pipe line 500 ft long

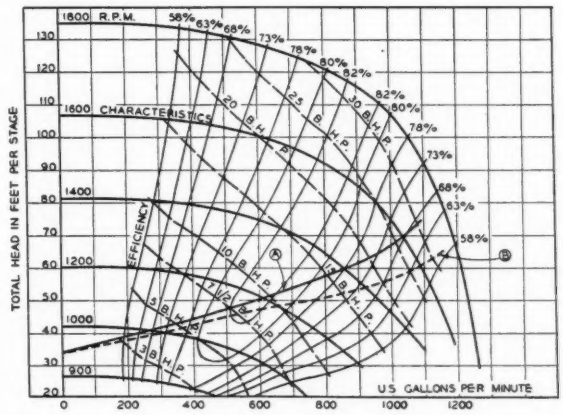


Fig. 2 Characteristics of a horizontal centrifugal pump operated at speeds ranging from 900 to 1800 rpm. Curves "A" and "B" are those shown in Fig. 1, superimposed on the pump characteristics. The head-capacity curve shown at "A" represents a condition in which water is pumped from a well into a pipe line. A pump, the characteristics of which are here represented, would operate at best efficiency when delivering 600 gpm with a total head of 50 ft and a speed of 1200 rpm if used under conditions represented by curve "A"

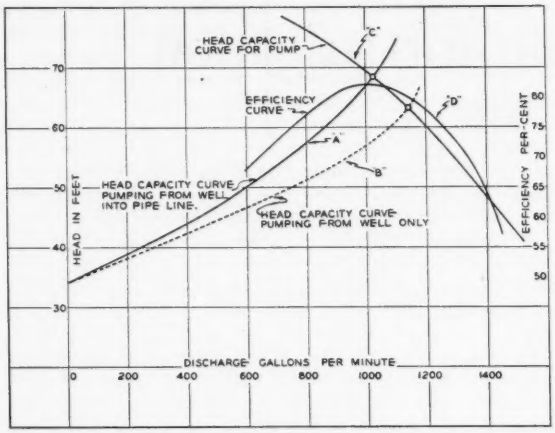


Fig. 3 Curves "A" and "B" are those shown in Fig. 2. Curves "C" and "D" represent the head-capacity and efficiency curves for a constant speed turbine pump. Under conditions represented by curve "A" this pump will develop efficiencies of slightly more than 80 per cent at a discharge of 1000 gpm, pumping against a head of 68 ft

The Centrifugal Pump. The pumps in general use today for irrigation operate on the centrifugal principle. One of the most common types is the single-suction horizontal centrifugal, so called because of the horizontal position of the shaft. The important features are the drive shaft, which may be belt driven or direct connected to an engine or motor; the impeller which may be of the open, semi-open, or enclosed type; and the volute or scroll case which surrounds the impeller and is so designed as to collect the liquid and direct it to the discharge line after being acted upon by the impeller. Since the action of the more complicated pumps of the double-suction and turbine type is similar, in many respects, to the pump just mentioned, a fairly complete description of its characteristics will be given.

The suction line enters at one side and conducts the flow to the center of the rotating impeller, where the fluid immediately takes up the same velocity as that rotating member and by centrifugal force is carried to the volute or scroll case, where the kinetic energy of the water is changed to pressure head. The principal losses which take place in the process just described are as follows:

1 Friction and eddy losses as fluid passes through the impeller

2 Shock loss when the fluid leaves the impeller at high velocity and enters the scroll case or volute where lower velocities obtain

3 Friction in the scroll case or volute

4 Leakage from the scroll case past the impeller and back to the suction side again

5 Mechanical friction of bearings and the drag between impeller and case due to relatively close clearances.

By improvement of design certain of these losses have been greatly reduced and the efficiency of this type of pump greatly increased. The efficiency of a pump of this type takes into consideration only the losses within the pump itself and not in the piping leading to and from it and is computed by the following formula:

$$\text{Efficiency} = \frac{\text{Horsepower applied to impeller shaft}}{\text{Water horsepower}}$$

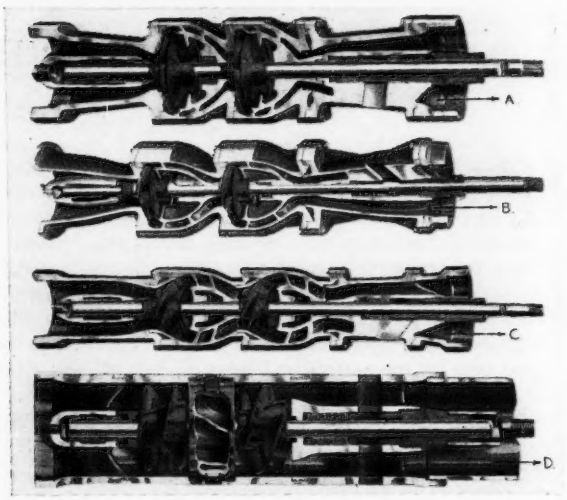


Fig. 4 Impellers of various designs from the strictly centrifugal type and the mixed-flow, to the axial-flow are shown at "A", "B", "C", and "D". A bowl assembly of the type shown at "A" is particularly adapted for pumping relatively small quantities of water to high heads per stage. Pumps of this type may be had for high-capacity discharge but the bowl is of relatively large diameter. Impellers of the mixed-flow type such as shown at "B" and "C" are adapted for raising large quantities of water from wells of rather small diameter. The head per stage is not so great as for type "A". An axial flow, deep-well-turbine pump bowl assembly is shown at "D". With this type of bowl assembly and impeller relatively large quantities of water can be drawn from wells of small diameter. The lift per stage is relatively small and efficiencies are somewhat less than with impellers of other types shown

Water horsepower, or the work actually performed by the pump in a stated time, is computed by the formula

$$\text{Water horsepower} = \frac{\text{Total head in feet} \times \text{gallons per minute}}{3960}$$

The term "total head in feet" in the above formula must embrace not only the static head, but the velocity head or the kinetic energy which the water carries away with it and the friction head in pipes, elbows, foot valves, etc. Ordinarily the velocity head is low and may, in most instances, be neglected in irrigation practice.

Manufacturers of the better class of pumping equipment are prepared to furnish data by means of which the purchaser may choose a pump of the proper design to meet almost any service requirement. It is, however, highly important to know the service characteristics, that is, the relationship of capacity in gallons pumped per minute to head in feet, of the pumping job for which equipment is to be selected.

The following actual example will serve for illustrative purposes: Water is to be pumped from a well and through 500 ft of smooth, new iron pipe to a point on higher ground from which a field can be irrigated. The total static head from the water level in the well to point of delivery is 34 ft, but a previous test of the well shows that the water level in the well draws down to a lower and lower level as more water is pumped, hence there is a new value for the static head for each pumping rate. The head due to friction in pipe line and elbows has a new value for each pumping rate, as has the velocity head. Fig. 1 shows a curve representing the service characteristic of a proposed installation such as has been described. The

heavy dotted line represents the static head at various rates of discharge while the solid line represents total head at various rates of discharge. Having at hand the operating characteristics of the several pumps under consideration, it is usually possible to choose one which will work efficiently.

The operating characteristics of a horizontal centrifugal pump are shown in Fig. 2. Head-capacity curves are given for a number of different impeller speeds, and it should be noted that, at any particular speed, the discharge becomes less as the head against which the pump must operate becomes greater; also, that at any given impeller speed the efficiency is greatest between some fixed limits of discharge. When impeller speeds are decreased the rate of discharge for any given head decreases and the point of greatest efficiency is obtained between new discharge limits.

For sake of illustration, the service characteristic shown by the heavy line in Fig. 1, representing conditions for which a pump must be chosen, may be drawn on the curve sheet shown in Fig 2. The combination of the manufacturer's curve sheet and the service characteristic will at once bring out about all the necessary facts. From the points where the service characteristic crosses the head curves for the various impeller speeds, the rates of discharge, the horsepower requirements, and efficiencies may be read directly. Or, for any given rate of discharge, the head, the necessary impeller speed, the efficiency, and the horsepower requirements may be ascertained.

The above discussion pertains to centrifugal pumps equipped with drives which permit a change of impeller speed. Many of the newer models of turbines and practically all direct-connected, motor-driven centrifugal units are designed to operate at uniform speed. Such pumps have a fixed head-capacity curve as shown in Fig. 3. It is evident that the last mentioned type must be much more carefully chosen for a particular service characteristic if high efficiencies are to be obtained. With variable speed units, the pump discharge may be adjusted to the well capacity without much difficulty.

The horizontal centrifugal pump is well adapted to pumping from streams, lakes, and shallow wells, or, in fact, for any requirement where the pump can be placed conveniently so that the suction head, including head due to friction in the suction pipe, will not exceed 15 ft. Greater suction lifts may give rise to undesirable conditions of flow near the eye of the impeller, which may in turn reduce the efficiency unless special design is employed. This type of pump is simple and rugged in construction and may be obtained for any capacity from 25 gpm. A popular size is the 6-in (referring to size of discharge), which has a capacity of from 600 to 1200 gpm depending on the head and impeller speed. As usually constructed, the suction line enters the scroll case at the center of one side but double suction types are available, in which water enters the case and the impeller from both sides. This arrangement gives better hydraulic balance and partially eliminates side thrust. Three distinct types of impellers may be had, the closed, semi-open, and open. The closed design is generally used where high efficiencies are desired, and where the water to be pumped carries little or no sand or grit.

In order that the suction head be kept below the maximum amount, it is often necessary to construct a pit to a point just above the water level when pumping from wells with a horizontal centrifugal pump. The motor or engine unit may be mounted in the pit or may drive the pump from the ground surface with a belt, although both arrangements have many undesirable features.

The Vertical Centrifugal Pump. The characteristics of the vertical centrifugal pump are not essentially different from those of the horizontal type. It is adapted to conditions where considerable fluctuation may occur in the height of the water table. The vertical pump is ordinarily run

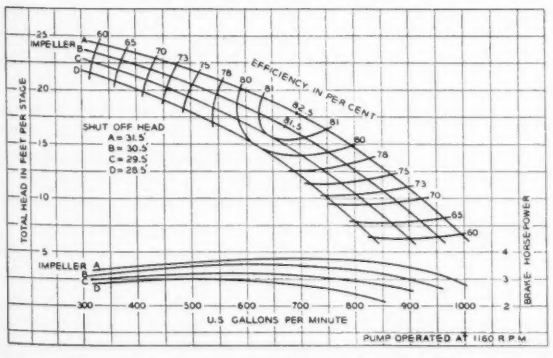


Fig. 5 Characteristics of a mixed-flow, deep-well turbine which develops its greatest efficiency when delivering a flow of 600 to 700 gpm with a head of 15 to 17½ ft per stage. The horsepower curves show the impeller to be of the non-overloading design

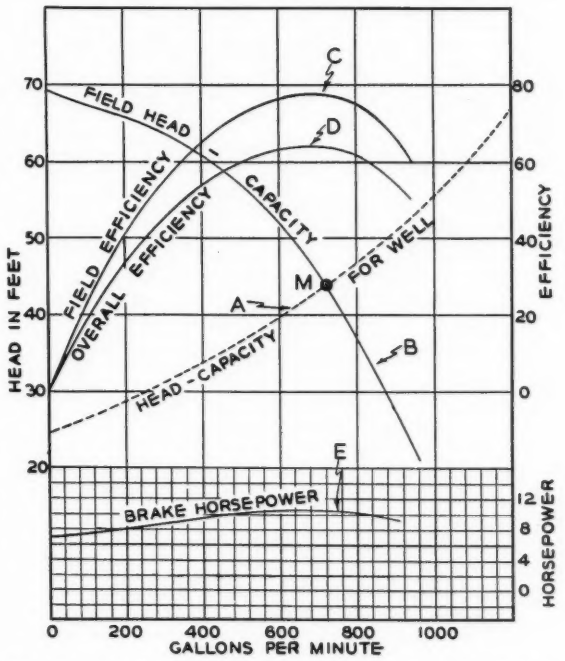


Fig. 6 (Adapted from Bulletin 433, Colorado State College) Curve "A", the head-capacity curve for the well, is determined by test. In this case the lift is 25 ft when the pump is not being operated. At a discharge of 600 gpm, the lift is 40 ft, due to the drawdown of the water surface in the well. Curve "B" is the head-capacity characteristics for a particular turbine-type pump at constant speed. It indicates the head against which the pump will deliver definite quantities of water. The crossing point (M) of the two curves "A" and "B" represents the point at which the particular pump in question will operate in this well. The discharge will be slightly over 700 gpm at a head of 44 ft. Curve "C" represents the field efficiency of the pump. That is the efficiency not considering losses in the electric motor. Curve "D" represents the overall efficiency which takes into account all losses, including that of the motor. It should be noted that the pump is well suited to the conditions to be met, since it operates at about the peak of efficiency. Curve "E" represents the horsepower required. This curve indicates an impeller which is so designed as to prevent overloading

submerged, and since the impeller shaft extends to a point above the ground surface, it may be driven conveniently with a belt. In some designs the shaft and discharge pipe are held in alignment by a heavy wooden or steel frame. In a more recent type the discharge pipe carries the load of the pump and holds the shaft bearings in alignment as well. Equipment of the type just mentioned cannot be used in wells of less than 24-in diameter nor for total heads much in excess of 50 ft.

The Turbine Pump. In the valley of the Platte River, where approximately 2,000 irrigation pumping units are now in operation, the so-called turbine pump has come into almost universal use in newer wells and many of the old horizontal, vertical, and rotary pumps are being replaced by it. Strictly speaking, the deep-well turbine is a true centrifugal pump of relatively small diameter, which is supported by the discharge column within which the drive shaft is located, and which has diffuser vanes in the case or bowl. The term "turbine" is now quite generally applied to almost all pumps which resemble the true turbine in any marked degree. An examination of "A" in Fig. 4, which shows a cutaway view of a two-stage turbine bowl assembly, reveals many characteristics mentioned in connection with other centrifugal pumps. Water entering vertically through the suction line is conducted to the lower impeller, from which it is discharged at right angles to the axis of rotation, to be guided to the upper impeller by the diffuser vanes. From the upper impeller delivery is made to a second set of diffuser vanes and then to the discharge column. The number of stages used depends not only on the head against which pumping must be accomplished but on the design of the bowl assembly, pump speed, etc. The characteristic of each design ordinarily indicates the head per stage at which the pump will operate efficiently. The tendency in modern turbine installations is to place the bowl assemblies well beneath the lowest point that the water level in the well or other source of supply is expected to drop. In wells, the suction line is commonly carried to within a foot of the bottom to remove any sand which may accumulate.

Fig. 4 A, B, C, D, depict various turbine bowl assemblies from that having an impeller of the true, closed centrifugal type, which discharges the water in a direction perpendicularly to the axis of rotation, to those of the mixed-flow and axial-flow design; the impellers of which are semi-open and impart an upward thrust to the water, or are of the screw variety. Many manufacturers are prepared to offer several designs of each type of impeller to meet almost any condition of flow or head. At a given discharge and speed, bowl assemblies with a true, centrifugal type impeller, must be larger in diameter than those of the mixed or axial-flow type but will develop high peak efficiencies under a high head per stage. The true axial-flow designs will deliver greater discharge at any given diameter of bowl at fair efficiency, but at low head per stage. Mixed-flow impellers partake partially of the good qualities of both and are becoming very popular for irrigation use. They are particularly well adapted to conditions where there is considerable variation in head and discharge. The semi-open, mixed-flow type of deep-well turbine impeller, as shown in Fig. 4 B, is well adapted to wells from which sand is discharged with the water. since it is not easily sand locked and can be adjusted for capacity by raising the impeller from the lower part of the case, allowing greater leakage back to the suction space. This reduces efficiency but under certain conditions may be justifiable. Fig. 5 depicts the characteristics of an impeller of the

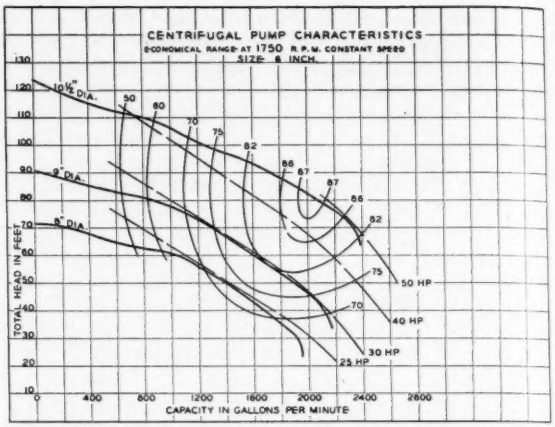


Fig. 7 Characteristics of a horizontal centrifugal pump operated at a constant speed of 1750 rpm but with impellers of various diameters ranging from 8 to 10½ in

mixed-flow type. The head curves "A", "B", "C", and "D" refer to different designs of the same general impeller type, each of which has separate characteristics. The horsepower curves on Fig. 5 indicate good impeller design of the non-overloading type. It may be observed that the horsepower curve reaches its highest point near the point of greatest pump efficiency. If the pump is ordinarily operated at this point, any change in head or discharge will result in less power being used and hence no danger to the motor.

The turbine pump, the characteristics of which are shown in Fig. 5, when using impeller "A", reaches an efficiency of 82.5 per cent when pumping 700 gal at a lift of 17.5 ft per stage, and the horsepower required at this lift and discharge is 3.75 per stage. In order to gain efficiency by presenting the smoothest possible surface to the water and at the same time use a material of great wearing qualities, some manufacturers line the bowl assembly with porcelain and make impellers of porcelain-lined cast iron. Ordinary cast iron and bronze are also used.

Lubrication of the drive shaft has presented somewhat of a problem in the past, but is now accomplished in some models by oil and in others by using water-lubricated rubber bearings. In some types the drive shaft is enclosed by an inner column of heavy pipe, on which combination couplings serve not only to connect the pipe but also as guide bearings. Oil supplied by gravity feed from the surface furnishes lubrication, drop by drop, to all but the one bearing below the impellers, which is ordinarily packed with nonsoluable grease. In water-lubricated models, the drive shaft may or may not be enclosed. Often it is centered by spiders which hold the rubber bearing assembly. The drive shaft is sometimes provided with stainless steel sleeves to prevent rusting and pitting at bearing points. Some water lubricated bearings require prewetting or priming before starting the pump, while others are said not to require it.

An important part of the turbine pump head is the thrust ball bearing, which must carry not only the weight of the shaft and impellers but also the hydraulic thrust. For the conventional belt drive, a pulley is mounted on the drive shaft and is often fitted with a non-reversing mechanism to prevent couplings from becoming unscrewed if the direction of rotation is accidentally reversed. The multiple V-belt on a straight and also quarter-turn arrange-

ment has been used for driving this and other types of pumps. In order to avoid long quarter-turn flat and V-belts, and to permit the direct connection of engine power units, the spiral, bevel-gear pump head is coming into more general use. Standard speed ratios of 1 to 1, 1.3 to 1, 1.5 to 1, and 2 to 1, as well as special ratios, may be obtained permitting the correct matching of power unit speed to that of the pump. Direct-connected, hollow-shaft motor drives are common on irrigation pumps where three-phase electric energy is available.

The Propeller Pump. Pumps of the propeller type are best adapted to raising large quantities of water through lifts of from 5 to 20 ft and, while generally used for pumping from streams or lakes, may however find some application in shallow wells of high yield and stable water level. Units with discharge capacities of from 600 to 50,000 gpm are available. The mechanism consists of a vertical discharge pipe in which is centered an exposed drive shaft with a two or three-bladed propeller mounted near its lower end. The methods of drive described in connection with the turbine may be used with this pump. When revolved at high rates of speed, the propeller lifts the water to vanes mounted above it which prevent excessive eddying and direct the flow in a direction parallel with the drive shaft. Under conditions of high yield and low lift, better efficiencies often may be developed than is possible with centrifugals.

Pump Efficiencies. The term "pump efficiency" is loosely used and little understood, not only by operators of irrigation pumps but by well drillers, pump salesmen, and others. It has little significance to the irrigator except as it is related to pumping costs. He is not interested in the fact that the pump bowl assembly develops a given efficiency, but in how much water he can get to the ground surface per dollar expended, when fixed as well as operating costs are considered. The various terms applied such as "bowl efficiency," "field efficiency," and "overall efficiency" may be understood from the following illustration as applied to a motor-driven turbine pump. The electrical energy flowing to the motor is considered as 100 per cent of the input power, while the power represented by the units of water lifted from the water surface to the ground surface in a unit of time is the output or water power. The power balance in an average turbine (with 100 per cent delivered to the motor) might be about as follows: 10 per cent motor loss, 1 per cent thrust-bearing loss, 1½ per cent column shaft loss, ¼ per cent entrance and friction loss in strainer, ¼ per cent friction loss in suction pipe, 13½ per cent loss through bowl assemblies, 1½ per cent hydraulic column loss, ¼ per cent elbow friction loss, and ¼ per cent velocity head loss.

This leaves 71½ per cent as the output or water power of the pump. It represents the actual work done in lifting a certain number of units of water through a certain head in a given time. It should be understood, of course, that the various losses given are relative, and may vary with the different designs of motors and pumps.

The overall efficiency of the particular pump just illustrated is 71½ per cent. It represents the relationship of the water horsepower to the total input energy. The field efficiency is the efficiency of the pump itself, not considering the motor losses. In this particular case, the field efficiency is 81½ per cent. The bowl efficiency takes into consideration only the losses in the bowl itself which, in this case, are 13½ per cent. It is evident that the term "efficiency" means little unless clearly defined.

$$\text{Water horsepower} = \frac{\text{Lift in feet} \times \text{gallons per minute}}{3960}$$

$$\text{Brake horsepower required} = \frac{\text{Water horsepower}}{\text{Field efficiency}}$$

$$\text{Motor input required} = \frac{\text{Brake horsepower}}{\text{Motor efficiency}}$$

In Fig. 6 is shown field and overall efficiency curves for a turbine pump, also a head-capacity curve for a well and the pump.

Power for Irrigation Pump Operation. Where irrigation pumps are used only to supply supplemental water during a brief period, tractors are the most common form of power. Gasoline is little used as a fuel at present due to high cost. Under the above conditions, rebuilt automobile and combine engines arranged to handle heavier fuels are used to a limited extent.

In drier sections where irrigation must supply the major portion of the moisture for crops, the tractor is not so much used, since it cannot be spared for so long a period from other farm operations. In these sections, tractor engine power units are becoming increasingly popular, as is the light, high-speed diesel. A popular plant for deep-well operation at present consists of a high efficiency turbine with a gear head permitting direct connection to a high-speed diesel. There is scarcely one of the old, heavy, slow-speed, belt-drive engines left in Nebraska at the present time.

There is great interest in electricity as a source of power for pumping at present, due to the formation of federal rural electrification districts and increased activity on the part of private utilities. In one Nebraska county, the contract is being let for heavy three-phase lines which are expected to furnish energy to 200 pump motors averaging 15 hp each. Most of these outfits to be served are now tractor operated and the land owner runs the pump at a speed for which his well will furnish adequate water. With electric power, the motor will in most cases operate at uniform speed, calling for belt and gear drives. Many of the pumps are of slow-speed types which will not permit direct-connected motors. It is evident that, unless careful design is used, power costs will be excessive in many cases due to mismatching of motor and pump. When properly used, electrical pumping plants are convenient and have the advantage of needing little attention during the irrigation season.

That there is great lack of uniformity in design and operation in pumping plants at present is evidenced by a survey of costs, made in the Platte Valley some years ago, which showed some outfits with operating costs as low as 2.9 cents per acre foot per foot of lift, while others averaged over 15 cents. In modern diesel-driven, deep-well pumping plants, engineering has pointed the way to successful operation for lifts up to 100 ft or more, but as yet the total cost of operation depends on too many factors to be accurately determined in advance. Much standardization of equipment and methods of installation is needed if the pump irrigator is to compete successfully with the ditch irrigator in dry years and the dry land farmer in good years.

Relation of Soils to Mechanical Erosion Control Structures

(Continued from page 318)

transportation by suspension, but the lack of tenacity in sands makes them susceptible to movement by rolling, and I believe all sands from coarse to very fine will establish a grade as flat, if not flatter, than the silt loam.

In our construction of dams we have used the above principles and secured these grades by placing structures farther down stream, by building a drop outlet, by excavating and placing the barrel below the gully bottom or with a permanent check dam below. Of these, excavating the barrel below the gully bottom and trenching an outlet, although generally the cheapest, is the least satisfactory, because it may endanger the necessary drainage of the barrel for winter. Sloughing of the undermined or of other fresh steep gully banks may supply more material to the channel than the water can remove, especially if the channel is long. The outlet may also be slowly blocked by sedimentation after the pond is filled and fertile sediment escaping through the dam is caught by irregularities and produces vegetative cover in the channel below, in turn promoting more sedimentation. A steeper grade can be built up under such conditions than would have been possible to maintain when the structure was first built. This ought to be considered in determining a probable safe grade at which to place the barrel. On the other hand, too much reliance ought not be placed on vegetation to maintain a very steep grade below a structure.

While a safe gradient below a structure is necessary to insure permanence, there is an additional problem at the outlet that is part of structural design rather than a soil problem. The discharge velocity from these structures is high, and below nearly all of them that have seen any length of service a hole has been gouged. It is impossible to design a structure at reasonable cost that will avoid this. Good insurance seems to be to extend the barrel far enough, or to construct a drop apron that will keep this hole outside the critical slope of the fill. This is all that is necessary, provided the gully below this hole has a stable gradient as outlined above.

BENEFITS DETERMINED BY QUALITY OF SOIL

Quality of soil enters materially into consideration as to whether or not the cost of permanent structures can be justified by the benefit. A common way to evaluate benefits of a structure is to use the market value of the acres of land directly threatened. In a state like Wisconsin with a climate that includes low winter temperatures, and in which dairying and other intensive livestock farming are the prevailing farm enterprises, approximately half the market value of a farm is in buildings. Farms are of moderate size and readjustments not feasible. Under such conditions the loss of 20 acres of land by encroachment of an outlet gully frequently reduces a farm from an economic unit to an uneconomic unit. Then the remnant of the farm has only the salvage value that an adjoining neighbor will pay. On this basis the damage that the large deep outlet gully and its cancerous branches has done is not that measured by the value of the 20 acres of land, but the value of the entire farm before gullying, minus the salvage value a neighbor paid at a forced sale. Further losses are that a farm family has been deprived of its chance to make a living and a political subdivision has a reduced tax base.

First cost of a permanent structure ought not be the one prime consideration, but effectiveness and permanence ought to come first, with proper regard for cost afterward. I know of numerous instances where farmers have used temporary dams and methods given prominence in erosion control literature with the result that they spent more money in the endless battle of repairing and rebuilding so-called cheap dams than the price of a good structure. Then if they had resources enough left, they finally built a permanent structure or in despair left the farm.

We believe firmly in the need for and desirability of sheet erosion control on all rolling agricultural land. After this is done, there will be enough uncontrolled runoff to destroy the usefulness, by dissection from below, of many farms located on the three classes of land described, unless the outlet gullies are controlled by properly designed, well-built permanent structures.

SOME OF THE BEST FLAT GRAIN AND HAY LAND IS SUSCEPTIBLE TO DESTRUCTION BY LARGE GULLIES EATING IN FROM THE EDGE. A LARGE, PERMANENT DAM IN THE OFFENDING GULLY MAY BE JUSTIFIED BY ITS PROTECTION TO 100 OR MORE ACRES

What Agricultural Engineers Are Doing

FROM THE U. S. BUREAU OF AGRICULTURAL ENGINEERING

AT THE request of the Soil Conservation Service W. W. McLaughlin, chief, Division of Irrigation, has been granted a year's leave of absence for the purpose of acting as technical adviser to the chief of the Soil Conservation Service. Effective July 1, 1938, A. T. Mitchelson will assume responsibility for the work of the Division of Irrigation under the title "Acting Chief".

* * *

The Act appropriating funds for the Department of Agriculture for the fiscal year 1939 contains two new items for the Bureau of Agricultural Engineering, as follows: Rural-Electrification Investigations, $30,000; and Fiber-flax Investigations, $25,000.

* * *

During the past month M. R. Lewis studied supplementary irrigation possibilities in Nebraska and South Dakota. He visited the vicinity of Grand Island and Kearney, Nebraska, in the Platte River Valley, where there is considerable shallow-well pumping. The need for financing farmers who do not have wells was discussed with the local people. The possibility of connecting up many of the present wells with the local electric power districts was also considered. Deep-well pumping in the area around Minden and Alliance, where there appears to be a good supply of water at depths of 100 to 150 ft, was discussed, but the economic feasibility of such pumping has not yet been demonstrated.

In South Dakota the proposed large projects at Lower Brule and Buffalo Gap were examined, the former being on an Indian reservation, where it is proposed to dig a tunnel or a deep cut through a narrow strip of land on the Missouri River to develop power for irrigation pumping. The Buffalo Gap project is for storage.

In both States consideration has been given to the possibility of providing irrigation under the terms of the Small Water Facilities Act. Numerous possible sites were noted, but no action can be taken until the regulations governing the use of funds have been worked out.

* * *

R. L. Parshall reports that tests were made of the pyralin type buovant turbine, mounted on a one-foot adjustable-tube orifice meter. For an actual loss of head through the device of 0.016 ft, the turbine indicated a very consistent rate of rotation. A small buoyant turbine of thin sheet brass was made and tried out with success. The use of such a rotating turbine as an accessory to the adjustable tube meter will obviate the actual measurement of pressure heads and permit calculating the rate of flow as a function of the rate of rotation of this turbine.

* * *

In connection with the proposed studies of evaporation from Silver Lake, in the Mojave Desert of southern California, A. A. Young established an evaporation station there to compare losses from a temporary body of water with those from a Weather Bureau pan and from a screen-covered pan. Arrangements were made with the Los Angeles Bureau of Power and Light to have their employees obtain daily records. It is expected that measurements will be possible for the greater part of a year. There is neither inflow nor outflow nor seepage loss at the present time and lake levels change only as a result of evaporation. Temperatures are high and at times there is considerable wind movement so that high rates of loss are expected during the summer.

* * *

In connection with the study of June-drop of fruit in relation to different irrigation treatments, Colin A. Taylor laid out plots on two orchards where difficulties have been experienced with set of fruit, one having loamy sand and the other rather heavy loam soil. To obtain data on over-irrigation troubles, particular attention will be paid to plots that are wetter than average.

* * *

During the past month instructions have been issued by the Director of the CCC, which establish the work program of the drainage camps as a definite part of the future Civilian Conservation Corps activity.

* * *

The policy approved by the director of CCC drainage work, which is essentially the same as is now in effect, provides for undertaking repairs or reconstruction of existing drains of organized drainage districts or associations of a public or quasi-public nature. Projects are to take into consideration public benefit through demonstrations or health aspects, in addition to providing for the preservation and conservation of improved productivity of agricultural lands. Districts or associations must give evidence that governmental assistance is required, that substantial cooperation is provided by them in connection with the work, and that the completed improvement will be maintained by them for a minimum period of five years without further assistance of the camps. Projects must be of such character as to provide for experience and training of enrollees in procurement of future gainful employment.

* * *

The Central District reports the following accomplishments for its camps during May: 1,415,977 cu yd of excavation and embankment, 3,865,410 sq yd of clearing, 39,565 lin ft of tile reconditioning, and 16,899 man-days used on structural and other miscellaneous work. A total of 74,522 man-days were used on project work during the month.

* * *

J. R. McCalmont has been at Ames, Iowa, supervising the filling of some new steel corncribs recently erected there. Observations are being made as to the stability of the cribs. Willis R. Swanson, who has been located at Ames on the corn storage work, has moved to Hays, Kansas where he will have charge of the wheat storage experiments this season.

* * *

W. P. Green left Southern California on June 9 with a test shipment of oranges, arriving in New York about June 18. Tests were made on various methods of icing the cars, including using ice in the upper half of the bunkers only. The tests included measurement of temperatures and air velocities at various points in the loads.

* * *

Mechanical thinning of sugar beets, which has been an experimental operation only, has been tried by E. M. Mervine over a wide area in Western Nebraska and various places in Colorado on a more nearly commercial basis this year. The enthusiasm with which it is being received indicates that it may be a successful method.

* * *

A preliminary survey of the data on the disk test work, where the tests were conducted in Davidson Clay soil, have shown that there is a sharp increase in draft as the speed increases up to 3 or 4 mph, depending on the angle at which the disk is set. Then there is a sharp decrease in draft between 5 and 6 mph. It appears that at low speeds the soil clings to the disk and causes the draft to be quite large. When the speed is increased the disk clears itself and there is a corresponding drop in the force required to pull it forward. The factor of speed in connection with the disk studies appears to have some interesting points.

* * *

Some shifting of the personnel of the division of mechanical equipment is contemplated in July. W. M. Hurst, formerly in charge of the project entitled, "Utilization and Cost of Farm Power and Machinery," is to be transferred to Oregon in July to take charge of a new project dealing with fiber flax investigations. John W. Randolph, in charge of the cotton production machinery studies, will succeed Mr. Hurst with headquarters in Washington, D. C. R. M. Merrill, in charge of pest control machinery investigations, will head the cotton machinery and tillage studies at Auburn, Ala., and Frank Irons, now associated with Mr. Merrill at Toledo, will then take over the pest control work.

* * *

The following publications relating to agricultural engineering have recently been issued by the Department of Agriculture:

"Farm Building Surveys in Illinois, Kansas, Wisconsin, and Georgia," by J. R. Dodge. Miscellaneous Publication 311.

"Cotton-Gin Brushes—Care and Repair," by V. L. Stedronsky and Arvid J. Johnson. Circular 467.

"Making Lime on the Farm," by N. A. Kessler. Farmers' Bulletin 1801.

Contributions Invited

All public service agencies (federal and state) dealing with agricultural engineering research and extension, are invited to contribute information on new developments in the field for publication under the above heading. It is desired that this feature shall give, from month to month, a concise yet complete picture of what agricultural engineers in the various public institutions are doing to advance this branch of applied science.—EDITOR.

NEWS

Washington News Letter

from AMERICAN ENGINEERING COUNCIL

"MANAGEMENT IS ON THE SPOT"

THE Seventh International Management Congress will be held in Washington from September 19 to 23, with headquarters at the U. S. Chamber of Commerce. American Engineering Council, by action of the Executive Committee has accepted the invitation to become one of the sponsoring organizations of this international meeting. We urge all those who can attend the meetings in Washington to take part in the deliberations of this epoch-making Congress.

The first Congress was held in Czechoslovakia in 1924, at the call of the government of that newly established nation. The Seventh Congress, the first to be held in the United States, has the approval of the Departments of State and Commerce. Secretary Hull will open the Congress. Secretary Roper will close it. Official invitations to the sixteen participating nations have been transmitted by the Department of State through diplomatic channels. It is expected that some three hundred delegates from abroad will meet with representatives of management in the United States to discuss together the responsibilities of management and the detailed consideration of technical phases of management in the field of administration, production, distribution, personnel, agriculture, and the home.

TVA HEARINGS

The opening hearing on the TVA inquiry under a Joint Committee of the House and Senate, were held in Washington on May 25, 1938. The opening hearings were limited to the reading of the formal written statements from the three directors of the TVA, Arthur E. Morgan, Harcourt A. Morgan, and David Lilienthal. The hearings then closed. The Committee will send investigators to the Tennessee Valley to obtain information on which to proceed when the hearings are resumed. The official records of the authority were opened to Arthur E. Morgan by Committee order.

Senator Donahey, Chairman of the Joint Congressional Committee, announced the appointment of Francis Biddle, of Philadelphia, as chief committee counsel. The Committee agreed to ask the Senate and House for $100,000 in addition to the $50,000 which had already been appropriated in the resolution creating it.

REVIEW OF ENGINEERING EDUCATION

The Engineers' Council for Professional Development, supported by a grant of $10,000 from the Carnegie Foundation for the Advancement of Teaching, has arranged for the preparation and publication of a "Report on Engineering Education in 1937." The work will be in charge of Dr. Dugald C. Jackson, president of the American Institute of Consulting Engineers, a member organization of the American Engineering Council.

It is expected that the Report on Engineering Education in 1937 will be ready for publication in a year. Copies will be distributed to engineering libraries and officials of the engineering schools and of the engineering societies.

RURAL ELECTRIFICATION LOANS

H. J. Res. 679 amends the REA Statute and makes $100,000,000 additional available for loans to rural electrical cooperatives through June 30, 1939. It also provides $1,000,000 for additional salaries and expenses of the Rural Electrification Administration. This Act which is about to go into effect does not include any new restrictions or regulations except "that materials acquired for rural electrification uses shall be of domestic origin if possible." Otherwise, the basis for loans, construction requirements, and general operating conditions are the same as those now in use.

An interesting implication regarding the expansion of rural electrification is found in Title I, Section I, Item d of the Emergency Relief Appropriation Act of 1938 which reads: "construction of —— electric transmission and distribution lines or systems to serve persons in rural areas, including projects sponsored by and for the benefit of nonprofit and cooperative associations." Under this authority it seems entirely possible for the Works Progress Administration to build rural electric lines and turn them over to sponsoring cooperative rural electric associations without obligation beyond the usual sponsors' contribution.

UNITED STATES HOUSING AUTHORITY

The United States Housing Act of 1937 has received a number of changes: (1) "The going Federal rate of interest" is now defined as the annual rate of interest specified in the most recently issued bonds of the Authority having a maturity of ten years or more. (2) The Administrator may delegate any of his functions and powers to any person in the employ of the Authority. (3) The Authority may make loans to public housing agencies to assist the development acquisition, or administration of low-rent housing or slum clearance projects by such agencies up to 90 per cent. In cases where there are annual contributions in assistance of low rentals, the total loans may equal the acquisition and development costs. (4) Annual contributions are now authorized up to $35,000,000 per annum. (5). The Authority is now authorized to issue obligations up to a total of $800,000,000, bearing interest not to exceed 4 per cent.

"RESEARCH TODAY" IN NEW ENGLAND

On May 20 the Engineering Societies of New England sponsored, in cooperation with the New England Council at six centers in New England, a series of simultaneous meetings on the place and purpose of research.

The general theme of the meetings was that no basic industry can remain static in the face of the tremendous scientific evolution that is proceeding apace. At Worcester, Massachusetts, president Ralph Earle and professor Kenneth G. Merriam, of the Worcester Polytechnic Institute, addressed a representative gathering. At Boston, Dr. Karl T. Compton, president of Massachusetts Institute of Technology and at Providence, Dr. Vannevar Bush, vice-president of the Massachusetts Institute of Technology spoke on the general topic. All speakers emphasized the fact that employment could come only through the development of organized industry and trade, and that research underlies the opportunity for more industries and for capital investment and employment in these industries. In general, they pointed out that the only way to get government agencies out of relief was to provide a basis so that business and industrial enterprise could make profit, so that wages could be paid, dividends declared, and new enterprices undertaken.

The American Engineering Council welcomes the opportunity to extend a wider knowledge of the plan and scope of these meetings to local engineering societies, in the belief that similar programs can do much to inform the public as to the basic contributions made by the engineering profession in the field of employment.

THE PARADOX OF PROGRESS

At the University of Illinois on the occasion of renaming the Materials Testing Laboratory the "Arthur Newell Talbot Laboratory," president Robert E. Doherty of Carnegie Institute of Technology, in a paper called "The Paradox of Social Progress," emphasized the relationship engineering and education bear to social progress and welfare. He pointed out particularly that while the economists maintain that prosperity and social progress within the profit system make it necessary continually to increase the efficiency of industrial production, this very process involving the full power of science, invention, and engineering increases rapidly the complexity of social organization, so that we apparently face the paradox that this very improvement in production, which would save us from economic and social collapse, would apparently also impel us ultimately to the same tragic fate.

President Doherty then points out the need of a planned education in the field of engineering, which shall prepare the young engineer to meet this complex situation. He believes that in a four-year educational program, perhaps the fourth of the total educational time should be arranged to lead to the following outcomes:

"(1) A clear historical understanding of the parallel growths of science and engineering, on the one hand, and social customs, relations, and institutions, on the other, and of how these have reacted on each other—in other words, a social consciousness and a historical perspective of social evolution, especially, but certainly not wholly, since the invention of the machine; (2) the ability to read purposefully in order to make a critical analysis of a problem involving social and economic elements and to arrive at an intelligent opinion about it; (3) the ability to organize thoughts logically and with purpose; (4) the ability to use the English language and thus express those thoughts effectively; and (5) a continuing interest in all these matters—in other words, the desire to become educated."

President Doherty believes that effective public understanding cannot be realized by a mere handful of broadly educated men.

He recognizes that the education of a professional citizenry is a long range process, but that unless we approach the proper professional education with this recognition of its economic and social implications we are headed toward a social chaos, and we will lose the opportunity for intellectual freedom, individual liberty to the greatest possible degree, and the incentive to constructive effort, which still symbolizes the American dream. President Doherty states that while these are timeworn phrases, they represent the ideals for which sacrifices have already been made in the United States in life, treasure, and change of view. The fundamental difficulty he says, "is complacency in professional America, a tendency toward frozen, or jelled, mental states. Will professional men on whose shoulders this responsibility rests, act in time?"

ECONOMIC STATUS OF THE ENGINEER

The Annual Assembly of the American Engineering Council in January recommended that the Executive Committee give consideration to the preparation of an informative pamphlet, particularly to help young men entering the engineering profession to understand the professional and economic phases of the engineers' relation to compensation for engineering services. As reported in the May Bulletin, the Executive Committee acted favorably on this idea and under the direction of the Engineering and Allied Technical Committee, of which Professor John S. Dodds is Chairman, steps are being taken to put this proposal into effect.

Meanwhile, it is of interest to quote the conclusions and recommendations of the Report of the Special Committee on Unionization of the American Society of Civil Engineers.

The Committee concluded, after reviewing the developments of the unionization movement, that within the Society itself there are diametrically opposed views. Some members hold that a man cannot be both a professional man and a member of a trade union. Others believe that it is possible for him to retain high professional values and at the same time to join his fellows in collective action. These opposing views arise from the fact, that Committee states, "that those who can see no good in unionism base their conclusions on knowledge of the bad practices of some of the trade unions rather than upon the fundamental principles upon which the unions are built. The principles are sound and now are the law of the land. Those who have turned to trade unions for the solution of their economic ills hold that the bad practices can be eliminated."

PUBLIC WORKS ADMINISTRATION

As the Public Works Administration clears its decks for the new 1938 program authorized by Congress, the "how, where, when, and why" of that program become major items of interest to architects, contractors, engineers, and all of those engaged in business and industry from which must come equipment, materials, and supplies for a public works construction campaign which may eventually involve as much as $1,866,000,000. All of that would be in addition to what is yet to be done to wind up construction of projects with an estimated total cost of approximately $1,000,000,000.

The 1938 Act authorizes a fund of $965,000,000 for allotments for "useful public works projects" of the kind and type heretofore carried forward by PWA.

Full financing must be provided for in plans for any project. The Act provides that no Federal funds are to be advanced to any public agency unless adequate provision has been made for financing the part of the project cost not supplied from Federal funds.

Projects can be carried out in every part of the United States. Non-federal projects can be undertaken by "States, Territories, possessions, political sub-divisions or other public bodies." Federal projects of certain classes can be constructed in the United States "including the Territories and possessions of Alaska, Puerto Rico, and Hawaii."

The only PWA project applications on which PWA can act are the official applications of public bodies authorized by local law and Federal statute to undertake qualified and justified public improvements. Authorized local public bodies can use their own judgment about whom they may consult, but PWA's action must be based upon procedure fixed by law. It is futile and wasteful for applicant bodies to seek to submit pleas through unusual channels or incur expense in the hope of securing favored treatment. In other words, sponsors are warned by PWA that it is unnecessary to employ lobbyists on any basis.

The program will go into action immediately. At the direction of the President PWA is preparing for allotment immediately after the signing of the bill, a list of projects with total construction costs of $600,000,000. That is being done from the 2714 pending projects, already chosen by hundreds of communities; and approved by PWA's legal, finance, and engineering divisions.

New applications for non-federal projects must be filed with PWA by midnight September 30, 1938 to be eligible for consideration under the provisions of the bill. This deadline does not apply to amendatory applications filed or applications which were submitted prior to October 1, 1937. Projects must be started prior to March 31, 1939 and substantially completed by September 30, 1940. This does not apply to any project enjoined in any state or federal court.

Applicants for Membership

The following is a list of applicants for membership in the American Society of Agricultural Engineers received since the publication of the June issue of AGRICULTURAL ENGINEERING. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Sven G. Anderson, assistant agricultural engineer, Soil Conservation Service, U. S. Department of Agriculture. (Mail) Federal Building, Watsonville, Calif.

Tom A. Bither, sales engineer, California Corrugated Culvert Co., Berkeley, Calif. (Mail) 754 Arlington Ave.

Hugh D. Broome, McBean, Ga.

Floyd J. Bunger, trainee, J. I. Case Company, Racine, Wis.

Elwin D. Butler, junior agricultural engineer, Soil Conservation Service, U. S. Department of Agriculture. (Mail) Box 187, Graham, Tex.

Humboldt Casad, Jr., Canutillo, Tex.

T. G. Dickenson, International Harvester Co., Richmond, Va. (Mail) Independence, Va.

P. H. Fitzgerald, Caterpillar Tractor Co., Peoria, Ill.

Frank R. Gentry, Box 192, Chillicothe, Tex.

Guy W. Halsey, trainee, J. I. Case Co., Racine, Wis.

Doyle F. Hammack, Box 420, College Station, Tex.

Harris H. Hart, trainee, Goodyear Tire & Rubber Co., Jackson, Mich.

Price Hobgood, Box 558, College Station, Texas.

David E. Jones, Inverness, Miss.

Herschel Klaas, student draftsman, agricultural engineering department, University of Idaho, Moscow, Idaho.

Gerald R. Kubin, Route 1, Box 62, Salem, Ore.

F. E. Larson, Webster, S. Dak.

John M. Larson, sales engineer, Northern States Power Co., Minneapolis, Minn. (Mail) 2103 Doswell Ave., St. Paul, Minn.

W. P. Law, Jr., Hydraulic Laboratory, Soil Conservation Service, U. S. Department of Agriculture. (Mail) Box 329, Spartanburg, S. C.

Thomas A. Marsh, Miskimon, Va.

W. Newton McAdams, Soil Conservation Service, U. S. Department of Agriculture. (Mail) Spartanburg, S. C.

Richard McCarthy, Jr., Godchaux Sugars, Inc., New Orleans, La. (Mail) 45 Farnham Place.

R. L. McElroy, 520 Sixth Avenue, Belton, Tex.

Raymond T. McVeety, trainee, J. I. Case Co., Racine, Wis.

H. L. Noel, Hillsboro, Miss.

Francis X. Olney, 909 Elm St., Columbia, Mo.

P. J. Patel, graduate student, agricultural engineering department, Iowa State College, Ames, Iowa.

Hugh G. Ramsey, Box 425, Blacksburg, Va.

LeRoy Reaves, Barrow Hall, Athens, Ga.

Harold R. Shaw, irrigation engineer, Waialua Agricultural Co., Ltd., Waialua, Hawaii.

Raymond L. Stevens, associate regional engineer, Soil Conservation Service, U. S. Department of Agriculture, Region 1, Williamsport, Pa. (Mail) 815 Hepburn St.

J. F. Stokes, Route 2, Forest, Miss.

James W. Stratton, Route 3, Pullman, Wash.

Donald K. Struthers, assistant extension specialist, agricultural engineering department, Iowa State College, Ames, Iowa.

Oscar C. Teigen, J. I. Case Co., Racine, Wis.

H. Raeburn Test, trainee, J. I. Case Co., Racine, Wis.

Donald C. Timberlake, Ellerson, Va.

Harold J. Thompson, agricultural engineering department, Iowa State College, Ames, Iowa.

Fred C. Yoder, Jr., trainee, J. I. Case Co., Racine, Wis.

TRANSFER OF GRADE

Irvin H. Althouse, consulting engineer, Irrigation Equipment Engineering Co., Box 87, Porterville, Calif. (Transfer from Member to Fellow.)

Truman E. Hienton, associate in agricultural engineering and experiment station, Purdue University, Lafayette, Ind. (Transfer from Member to Fellow.)

H. S. Pringle, agricultural engineering department, Cornell University, Ithaca, New York. (Transfer from Junior Member to Member.)

Agricultural Engineering Digest

A review of current literature by R. W. TRULLINGER, principal agricultural engineer, Office of Experiment Stations, U. S. Department of Agriculture.

STUDIES ON THE MANUFACTURE OF INSULATING BOARD, *O. R. Sweeney and L. K. Arnold.* Iowa Engin. Expt. Sta. Bul. 136 (1937), pp. 75, figs. 30. This is a report of studies which were conducted for the purpose of improving existing processes for the manufacture of insulating board from cornstalks and other agricultural by-products. Miscellaneous experiments were completed on cooking and refining of pulp, wax sizing, forming, drying, air infiltration, and dusting.

The results of cooking and refining studies indicated that excellent insulating board may be made from cornstalk pulp cooked 3 hr in water at atmospheric pressure. Such board is lighter in color than pressure-cooked pulp board and stronger than mechanical-pulp board. The addition of repulped newspapers or other waste paper up to about 20 per cent improves the strength of the board. While it is convenient and economical under present conditions to use waste paper in this manner the same result could be secured by adding more highly cooked and refined cornstalk pulp in about the same proportions.

Very good insulating boards were made from cornstalk-straw mixtures, sorghum cane, tobacco stems, artichoke stems, and milkweeds. Boards are being made commercially from wheat straw and cornstalks and have been made from mixtures of straw and cornstalks. The practicability of the use of the other materials is dependent upon their availability in sufficient quantities at reasonable prices rather than on technical difficulties.

The wax sizing showed that the optimum hydrogen-ion concentration for sizing with wax size is pH 4.5, which agrees with results previously obtained with rosin size. The optimum amount of size was shown to be about 6 per cent, but even with this amount of size the moisture absorption was higher than that usually obtained with rosin size. This high absorption, together with the large amount of size required — 6 per cent as compared with 3 per cent rosin size — indicates that wax sizing is not practical for ordinary purposes.

Wax-sized boards dried at 200 C. had higher strength and lower moisture absorption than those dried at 100 or 175 C. The lower temperatures are more likely to be used commercially than 200 C, however, since the latter corresponds to a steam pressure of 210 lb per square inch. Boards dried at 100 C showed greater strength when dried to 5 per cent moisture content than when dried to either greater or less moisture content.

In the forming studies it was found that the improved forming machine operated very well using pulps of varying freeness, and it produced a board which was superior in formation to boards from other types of machines. The older type using a suction box with a stationary top is in successful operation commercially and, from the results in the laboratory, it is believed that the improved type will be even more successful. One of the advantages of both of these forming machines is that they produce a board which is not laminated but which is composed of highly interlaced fibers. When the improved machine was operated at a rate of 4 ft 8 in per minute, equally good boards were produced at consistencies of 1.25 and 2.5 per cent. At lower speeds stronger boards were produced at lower consistencies.

Surface coatings were applied to boards by three procedures: (1) Floating the pulp for the outer layer on the surface of the mat on the forming machine from an auxiliary head box, (2) laying sheets of paper on the wet mat as it entered the press rolls; and (3) spraying pulp on the surface of either the wet mat or the dry board.

In forming the board mats on a stationary sheet mold it was found that little was gained in moisture reduction by exceeding 5 min in time or 8 in of mercury vacuum. These results apply to stationary sheet molds, but not necessarily to continuous forming machines.

Increasing the pressure applied to the board prior to drying increased both weight and strength of the board. Stronger and heavier boards can be produced by drying in a press under light pressure than by drying in the regular drier. If the pressure in the press is increased sufficiently a hard type of pressed board having low insulating properties is produced.

Drying was more rapid at 130 C than at 120 or 100 C. There was a straightline relation between rate of evaporation and moisture content down to about 60 per cent (dry basis). Boards which had once been dried in the normal manner, and then soaked, dried more rapidly than newly formed mats of board.

When boards were dried at ordinary room temperatures on racks, drying was more uniform when the distance between the boards was 1½ rather than ½ or 1 in. Apparently the wider spacing allowed better air circulation. In the heated but not air-conditioned laboratory in the winter, boards on racks dried to satisfactory moisture content in 4 days. While no humidity readings were taken the humidity under the existing conditions must have been low. The drying time for boards on racks outdoors in summer but protected from the weather was from 10 to 14 days. The drying time for winter outdoor conditions was much longer. Actual drying time is dependent on the temperature, very little drying occurring below freezing.

All of the boards dried in the heated building warped considerably, probably because of the low humidity; while boards dried outside showed practically no warping. Boards piled with strips of board as spacers sagged between the strips. The most practical method of drying was to place the boards on the wire-covered frames supported upon racks at a 30-deg angle, with the frames 3 in apart.

As would be expected, the drying time was dependent upon temperature and humidity, varying from a few days inside the heated building to several months for outside drying in winter weather. Except for warping, boards dried on the racks and those dried in the drier were equally satisfactory.

Insulating board dried more slowly in the hydraulic press than pressed board. The results indicate that the rate of drying of insulating board in an hydraulic press can be increased by (1) increasing the temperature of the platens, that is, the drying temperature; (2) increasing the freeness of the pulp, that is, using less hydrated pulp; (3) increasing the pressure on the board; and (4) heating the pulp or the cornstalks used for the pulp above 125 deg while dry before the final refining and board formation.

The infiltration through cornstalk insulating board may be reduced by increasing the paper content, by increasing the density, or by applying a surface coating of paper pulp. A board practically impervious to infiltration can be produced by the use of the paper coating.

Studies on the dusting of cornstalk insulating board showed that (1) the use of a fine mesh top wire (such as 40 mesh) or a felt on the press rolls will reduce dusting on the top surface of the board, and (2) coating the surface of the board with paper pulp or spraying with a solution of tung oil in kerosene or with sodium silicate reduced dusting. These materials were more effective when applied to the wet board mat as it comes from the press rolls than when applied to the dry board.

GEOLOGY AND GROUND-WATER RESOURCES OF OGDEN VALLEY, UTAH, *R. M. Leggette and G. H. Taylor.* U. S. Geol. Survey. Water-Supply Paper 796-D (1937), pp. IV + 99-161, pls. 6, figs. 11. The results of an investigation are reported of the ground water resources of the Ogden Valley, and data are presented on amount and quality.

The waters of Ogden Valley are satisfactory for domestic use and most industrial uses, but some of them are harder than is desirable for certain purposes. The fluoride content of samples of water from seven wells was determined, and it was found that these waters are not likely to be objectionable on account of their fluoride content.

IRRIGATION INVESTIGATIONS BY THE MONTANA STATION. Montana Sta. Rpt. 1936, pp. 33, 34. The progress results of investigations on sources of irrigation water are briefly summarized.

FARM IMPLEMENTS AND MACHINERY, *S. J. Wright.* Jour. Roy. Agr. Soc. England, 97 (1936), pp. 210-236. This analytical review, prepared by the Institute for Research in Agricultural Engineering of the University of Oxford, relates to power farming, tractors, cultivating implements, harvesting, grass conservation, and the use of electricity in farming. *(Continued on page 332)*

GOOD SALADS *and* GOOD METALS

...have much in common!

THIS picture of a cultivator unit operating in a California field of lettuce suggests the comparison.

For a good salad requires skilled blending of a variety of ingredients, and so does a good metal. Take the Nickel Alloy Steels and Nickel Cast Irons for example, two metals that tractor and implement manufacturers can use to such excellent advantage.

Both of these materials are composite mixtures containing Nickel, with the various ingredients carefully proportioned to obtain improved properties and improved performance.

As a result, these alloys show materially greater strength and toughness than the simple steels and irons and are more highly resistant to stress, shock, impact, abrasion and wear.

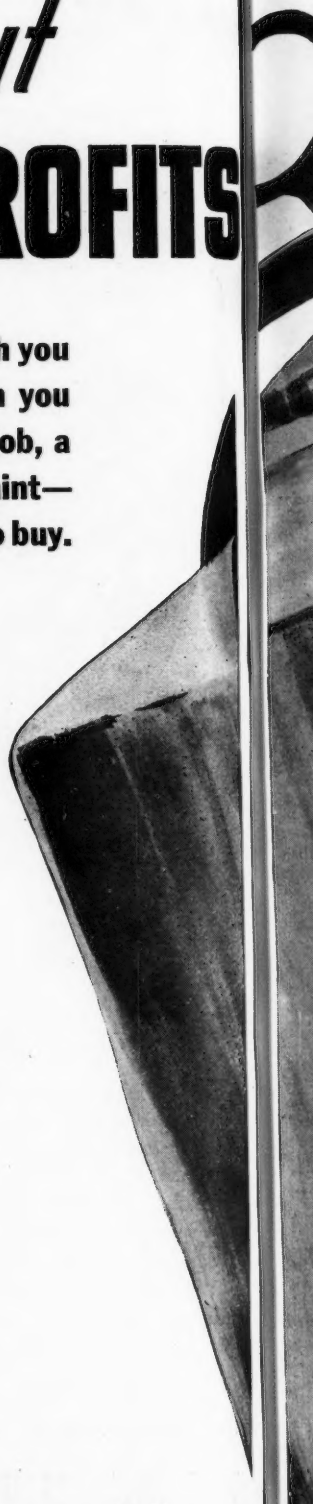
There are many applications where these alloys of Nickel are being used to advantage in agricultural equipment. Our engineers and casting specialists will be glad to consult with you and to advise uses and compositions that meet your requirements.

NICKEL ALLOY STEELS CAST IRONS

THE INTERNATIONAL NICKEL COMPANY, INC., 67 WALL ST., NEW YORK, N. Y.

How to thaw out
FROZEN TRACTOR PROFITS

Every traded-in tractor on your lot represents cash you didn't get when you sold a new tractor. How can you turn those tractors into cash? A reconditioning job, a changeover to high compression, a little fresh paint—and you'll have a tractor that farmers really want to buy.



THERE are three ways to look at a traded-in tractor. You can write it off as a loss, forget about it and salvage the parts that are still good. That's cash out of your pocket.

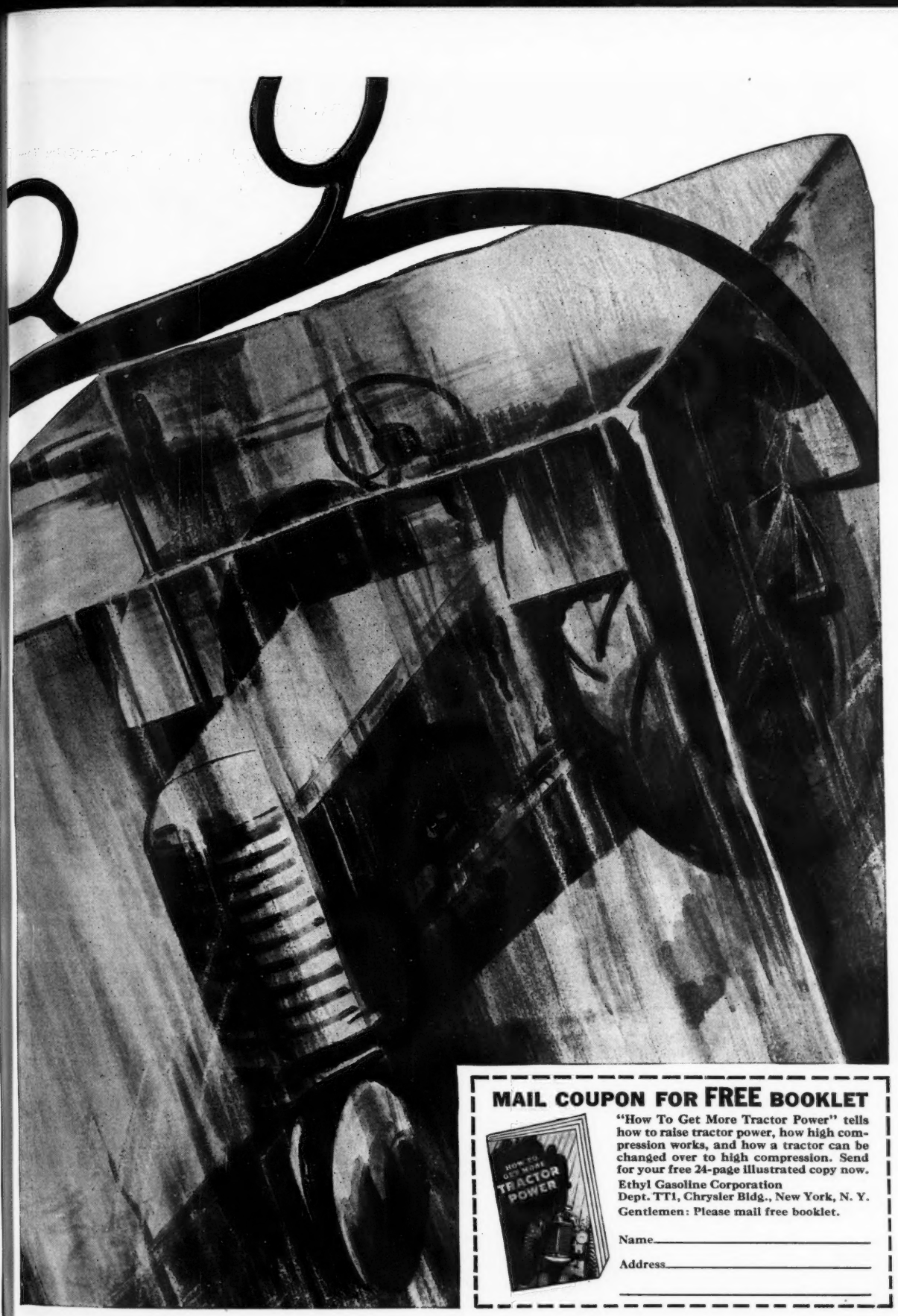
Or you can hope that somehow, somewhere, sometime, somebody will come along and buy it. That's fooling only yourself. You're still out money most of the time.

Or you can recondition it, change it over to high compression, paint it up, and make it a tractor that farmers want to buy. And that's one good way to turn tractors into cash.

Undoubtedly there are some trade-ins that should be junked. But many tractors are hardy machines good for many years of service. And there are many farmers in your territory who can't buy new tractors, but who can afford to pay for a reconditioned, high-compression tractor.

So what? Most tractor manufacturers today offer the "altitude" pistons or high compression heads that are necessary to change a tractor over to high compression. In most cases a change of the manifold damper from "hot" to cold position is the only change needed there. In others a new "cold" manifold can be obtained for a nominal cost. When new spark plugs are put in, make sure that they are the "cold range" type. Whatever other reconditioning may be necessary, your machine shop can decide. Then a fresh coat of paint, and you've got a tractor that farmers around you want to buy.

It has the added power, speed and economy of high compression. *That's* what farmers want. It looks like a capable, dependable machine. *That's* what farmers want. And because of its low price, it has a market far greater than that for new tractors. And *that's* what *you* want, because it gives you a chance to sell it and really make your profit on new tractors. Ethyl Gasoline Corporation, Chrysler Building, New York, New York, manufacturer of anti-knock compounds used by oil companies to improve gasolines.



MAIL COUPON FOR FREE BOOKLET

"How To Get More Tractor Power" tells how to raise tractor power, how high compression works, and how a tractor can be changed over to high compression. Send for your free 24-page illustrated copy now.

Ethyl Gasoline Corporation
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Gentlemen: Please mail free booklet.

Name_____

Address_____

Agricultural Engineering Digest

(Continued from page 328)

THE PERMEABILITY OF WOODS TO LIQUIDS AND FACTORS AFFECTING THE RATE OF FLOW, *H. D. Erickson, H. Schmitz, and R. A. Gortner.* Minnesota Sta. Tech. Bul. 122 (1937), pp. 42, fig. 1. Studies are reported on the longitudinal permeability of a number of species of wood which has been determined on both the heartwood and sapwood in the seasoned and unseasoned conditions. The effect on permeability of duration of continuous flow, seasoning, and various liquids was also studied, and the comparative permeability of heartwood, sapwood, springwood and summerwood was found for several species.

In general, the rate of flow of liquid through wood decreased with continued flow and approached equilibrium after about 3 hr, depending upon the kind of wood. The decrease in flow with time was generally considerably greater with water than with zinc chloride solution or commercial benzene.

The ratio of the sapwood to heartwood permeability varied for each of the three species tested. The ratios for a given species differed, usually depending on the liquid used and to some extent on the seasoning treatment. On the basis of increasing ratio of sapwood to heartwood permeability, the order was paper birch, western hemlock, and coast Douglas fir. The comparative permeability of sapwood to heartwood is probably very different for the various species.

The change in the permeability of sapwoods caused by seasoning varied with the kind of wood. With a few exceptions, no great change occurred with seasoning. Seasoned heartwoods were generally about as permeable as the unseasoned. Either pit aspiration does not occur as extensively and intensively as reported in the literature, or else it does not greatly influence longitudinal permeability.

The kind of liquid used very definitely affected the equilibrium rate of flow in practically all of the woods. The order of increased flow was water < zinc chloride solution < benzene. The initial rates of flow of the liquids also differed under certain conditions and with various woods.

The character of a liquid may so affect the permeability that the viscosity factor may be completely obscured. There is evidence that electrokinetic effects and polarity of the liquid affect the flow of liquids through wood. Successive changes of water and zinc chloride solutions forced through one kind of wood were accompanied by definite differences in the trend of the rate of flow. Apparently the pore size of the wood membrane was not permanently affected by the salt.

Woods differ in their permeability to a given liquid both in the magnitude of flow and in the extent of the decrease in the rate of flow with time. Springwood was considerably more permeable longitudinally to water than the summerwood in the seasoned and unseasoned sapwoods of two southern pines. Under the conditions of the experiment, resin ducts apparently did not assist the flow of water through the sections.

The unseasoned sapwoods of the species studied have a limited range of permeability. The majority fall within a spread of about 100 per cent. The unseasoned heartwoods exhibited a wider range of permeability and less uniformity, as a group and individually, than did the sapwoods.

The orders of arrangement of the woods based on final rates of flow are given. With unseasoned sapwoods the orders are about the same for both water and zinc chloride solution. The orders of arrangement of seasoned sapwoods are shifted somewhat from that of the unseasoned sapwoods, but are not greatly different for the three liquids. The orders of arrangement of the heartwoods are essentially alike for the three liquids used and for the seasoned and unseasoned sections.

A list of 34 references to literature bearing on the subject is included.

CORNSTALK ACOUSTICAL BOARD, *L. K. Arnold, H. J. Plagge, and D. E. Anderson.* Iowa Engin. Expt. Sta. Bul. 137 (1937), pp. 47, figs. 19. This report describes apparatus for the automatic determination of reverberation time, together with a method of operation, which is believed to be rapid and accurate. Studies are reported on the effect of composition and surface treatment upon the coefficient of sound absorption of cornstalk acoustical board and upon the effectiveness of the board when installed on the underside of chairs and tables.

It was found that cornstalk acoustical board made from mechanical pulp had a greater sound absorption than board made under similar conditions from steamed pulp. Paper pulp added to cornstalk acoustical board made either from mechanical or steamed pulp reduced the coefficient of sound absorption. Up to a certain point, depending upon the absorptiveness of the basic board and the size of the grooves, the addition of grooves increased the sound absorption in proportion to the number of grooves added. Effective acoustical board was made by surfacing soft cornstalk insulating board with cornstalk pressed board in which holes were drilled. The absorption increased in proportion to the number of ¼-in holes added, up to 225 holes per square foot. Certain hollow types of cornstalk board were more effective acoustically for the amount of material used than solid boards. Cornstalk acoustical board when attached to underside of table tops and chair seats up to amount applicable under practical conditions was only slightly less efficient than when tested under standard conditions.

FLOW OF WATER THROUGH 6-INCH PIPE BENDS, *D. L. Yarnell.* U. S. Dept. Agr., Tech. Bul. 577 (1937), pp. 118, pls. 2, figs. 103. This bulletin presents the results of studies conducted cooperatively by the Bureau of Agricultural Engineering and the University of Iowa. It reports a series of experiments on the flow of water through bends in a 6-in circular pipe with various amounts of total curvature, on 90-deg bends of hyperbolic and elliptical cross section, on a 90-deg bend of circular cross section with varying radius of curvature, and on a 90-deg miter bend. The research included cases with uniform and with nonuniform velocity distribution in the pipe approaching the bend.

The investigation was planned to cover measurement of (1) velocity distribution in the bend and in approach and discharge tangents, (2) pressure changes at various sections in the bend and the tangents, (3) energy changes as the water passes around the bend, (4) loss of head due to the bend, (5) directions of the filaments of flow as the water moves around the bend, and (6) friction losses occurring in the approach and discharge tangents.

It was found that all bends act as obstructions to flow, causing greater loss of head than an equal length of straight pipe. The velocities of the filaments along the inner side of the bend are increased and those along the outer side are decreased from their velocities in the tangent approaching the bend. The loss of head increases with increase in length of the bend, for pipe of equal size, equal radius of curvature, and like material and condition, and is greatest for a bend in which the tangents are joined without an intervening curved section. The ratios of the loss in head caused by the other round-pipe bends to that caused by the 90-deg standard bend were approximately, for the 45-deg bend, 0.75; for the 180-deg continuous-curvature bend, 1.25; for the 180-deg reverse-curvature bend, 2.1; for the 270-deg bend, 2.7; and for the miter bend, 7.8.

For a given pipe bend and given quantity of flow, the head loss in the bend is influenced greatly by the velocity distribution in the approach tangent. With velocity in the approach tangent high toward the inner side, the losses of head shown by all the bends ranged from about 1.5 to 4 times that obtained when uniform velocity prevailed in the approach tangent. With the approach velocity high toward the outer side, some bends showed slightly less and some slightly greater losses than obtained with uniform velocity of approach. With high velocity at the top of the approach tangent the loss for each bend was between 1.25 and 2 times that obtained with uniform approach velocity, and with approach velocity high at the bottom the loss was between 1.3 and 3 times that obtained with uniform velocity. These ratios were obtained with a high velocity along one side of the approach tangent about 3 times the low velocity along the other side. From the difference between the pressures on the inner and outer sides of a bend at the point of maximum differences, and having the size of pipe and the radius of curvature of the bend, it is possible to compute the mean velocity and therefore the quantity of flow. When a pipe bend has been calibrated it may be used as a flow meter with which the discharge can be determined by measuring merely the difference in pressure. The losses in the pipe bends experimented upon appear to vary as the square of the velocity, and not as the 2.25 power as suggested by some writers.

MODERN ELECTRIC AND GAS REFRIGERATION, *A. D. Althouse and C. H. Turnquist.* Chicago: Goodheart-Willcox Co., 1936, 2. ed., pp. [10] + 858, figs. 368. This is the second edition of this handbook. It contains chapters on fundamentals of refrigeration, the compression system, the absorption system, conventional domestic compression cycle refrigerators, domestic rotary and hermetic compression cycle refrigerators, domestic absorption refrigerators, domestic automatic controls, domestic refrigerator electric motors and gas supply, domestic refrigerator cabinets, domestic refrigerator installations, domestic refrigerator servicing, service tools and the refrigerator service shop, commercial refrigeration cabinets and mechanisms, commercial refrigeration calculations and heat loads, commercial refrigeration installation and servicing, refrigerants, technical characteristics, air conditioning, domestic refrigerator specifications, school refrigeration laboratory projects, and answers to review questions. *(Continued on page 334)*

Goodyear helps you clinch NEW TRACTOR SALES

GOODYEAR tire advertising talks to *your* prospects—boosts *your* business.

We're out to help you clinch more tractor sales—and here's how we're doing it:

Every ad in Goodyear's big 1938 farm campaign for tractor tires carries this headline: "GET A NEW TRACTOR ON GOODYEARS."

Every ad tells the farmer *why* he should trade in his old tractor for a new one.

Every ad urges him to see his tractor and implement dealer *now!*

And every ad points out the advantages of the better grip—the harder pull—the easier riding—the longer wear—of Goodyear Sure-Grip tires.

To tie up to this sales-making program *you* should be familiar with these advantages, too. And on all your factory orders—

Specify—

Save time and tires with Goodyear L.T. Semi-Drop Center Rims. Most efficient rim built—easiest to apply and remove tires. No special tools needed. Also available for dealer change-overs.

ONLY the GOODYEAR SURE-GRIP provides ALL these advantages

OPEN-CENTER TREAD—no pockets to pack up and cause slip; full self-cleaning; better penetration

WIDER TREAD—greater traction; more pull

BETTER GRIP—lugs are deeper cut and wider spaced to dig in without shearing off soil

SMOOTH RIDING—lug bars overlap evenly at center, giving continuous support on hard roads

GREATER FLEXIBILITY—conforms better to rough ground

REENFORCED LUGS—buttressed at both sides to prevent undercutting

WEATHERPROOF RUBBER—resists effects of sun, weather and barnyard acids

SUPERTWIST CORD in every ply

Sell KLINGTITE BELTS, too

KLINGTITE is the best-known farm belting on the market. Stock this profitable Goodyear product and take advantage of its great popularity.

GOODYEAR

TRACTOR AND IMPLEMENT TIRES

Agricultural Engineering Digest

(Continued from page 332)

THERMAL SPRINGS IN THE UNITED STATES, *N. D. and H. T. Stearns and G. A. Waring.* U. S. Geol. Survey, Water-Supply Paper 679-B (1937), pp. IV + 59-206 + IV, pls. 10, figs. 7. This publication brings together information relating to the important thermal springs of the United States.

THE FLOODS OF MARCH 1936.—PART 1, NEW ENGLAND RIVERS. U. S. Geol. Survey, Water-Supply Paper 798 (1937), pp. X + 466, pls. 14, figs. 41. This volume presents some of the important facts regarding notable floods in New England rivers during 1936.

WATER LEVELS AND ARTESIAN PRESSURE IN OBSERVATION WELLS IN THE UNITED STATES IN 1936, *O. E. Meinzer and L. K. Wenzel.* U. S. Geol. Survey, Water-Supply Paper 817 (1937), pp. III + 511. This report is the second of an annual series on ground water levels and artesian pressure. It gives records in observation wells in 28 states and the Territory of Hawaii.

THE UTILIZATION OF HEAT FROM ELECTRIC SURFACE UNITS BY CERTAIN COOKING UTENSILS, *L. J. Peet and L. O. MacDonald.* Iowa Sta. Res. Bul. 12 (1937), pp. 57-88, figs. 15. The purpose of this investigation was to determine the temperature distribution from 10 different types of units over the surface of a cooking utensil and to study the variation in the boiling time and the variations in typical short- and long-time cooking processes, using utensils of aluminum, enamelware, and copper. The kilowatt-hour consumption when boiling water in aluminum and enamelware teakettles and in stewpans of equal capacity was also determined. All utensils were of medium weight, with straight sides, flat bottoms, tight-fitting lids, and had an approximate capacity of 2 qt. The units were of the incased, embedded, open and enclosed labyrinth, and reflector types. The following are some of the conclusions noted:

The distribution of temperature over the surface of an electric unit is fairly uniform and is only slightly lower at the outer edge. For heating water and for cooking small potatoes and navy beans, typical short- and long-time cooking processes, respectively, the three types of utensils were practically equal in efficiency. The cooking processes when started on cold units were completed in the shortest time on the incased units, while the open units required slightly longer and the enclosed labyrinth, embedded, and cone reflector units the longest time. When preheated units were used the incased required the least time, the open, embedded, and enclosed labyrinth slightly longer, and the cone reflector type considerably longer time. Water heated in teakettles and stewpans of the same material and capacity required approximately the same time. The material of the pan has comparatively little effect on the cooking efficiency. The aluminum pan with a black-bottom finish tended to show a slightly increased efficiency, but there was no significant difference between the enamelware black-bottom and natural finish pans.

FARMERS GRAIN ELEVATORS: FACTORS INFLUENCING THEIR SUCCESSFUL OPERATION, *L. J. Norton.* Illinois Sta. Circ. 476 (1937), pp. 18, figs. 3. This circular, dealing with the factors influencing the successful operation of farmers' grain elevators, is based chiefly on data for the year ended June 30, 1936, for 88 farmers' elevators. Rates earned, effects of volume of business on earnings and of volume of grain and proportion of merchandise sales of total business on expense per dollar of sales, gross margins earned on grain, earnings from merchandise, and net worth of companies are discussed. A set of questions designed to assist in the analysis of an individual company is included. Some of the findings were as follows: " With profit margins and expenses as they were in 1935, a company would have to handle around 300,000 bu of grain or supplement the grain business with an equivalent volume of merchandise business in order to earn ordinary rates of return on the capital required in the business. . . . . Expenses of operation decline as the volume of grain handled increases. . . . . The margins taken on merchandise average about three times as large as those taken on grain, when measured by percentage of sale value. This higher margin approximately measures differences in costs of handling merchandise and grain. Margins taken on merchandise decrease as the volume of grain handled increases and as the relative importance of merchandise in the business decreases. The gross margin earned on grain is not closely correlated with the volume of grain handled, except for corn, where the margin declines with volume. The variation from year to year in margin per bushel of grain is closely related to the trend in the price of grain during the year. . . . Differences in margins earned on grain, more than any other factor, explain the differences in the earnings of the companies handling adequate volumes of business. The rate at which merchandise is turned over influences the capital requirements of a merchandise business. Companies handling relatively little merchandise have more rapid turnovers than those for which merchandise sales are more important. Receivables materially increase capital requirements. As an average for the companies studied, receivables represented nearly 40 per cent of the current assets."

PHOTOSYNTHESIS OF CHLORELLA IN HEAVY WATER, *F. N. Craig and S. F. Trelease.* Amer. Jour. Bot., 24 (1937), No. 4, pp. 232-242, figs. 7. It is inferred from the results of the experiments described that H_2O, as well as D_2O, enters into the dark stage rather than into the photochemical stage of photosynthesis.

PHOTOSYNTHESIS AND THE ABSORPTION SPECTRA OF PLANT PIGMENTS, I, *G. R. Burns.* Amer. Jour. Bot. 24 (1937), No. 5, pp. 257-265, figs. 3. In continuation of studies by the Vermont Experiment Station relative to the mechanism of photosynthesis an attempt is made to evaluate the known errors and to describe the experimental method in such a way that "the magnitude of the factors of which we are not aware, but which influence the results, may be correctly estimated." By a method described, the relative amounts of photosynthesis by white pine in different portions of the spectrum may be calculated from physical measurements. The results obtained showed general agreement between the observed and calculated values for photosynthesis and indicate that, other things being equal, the "primary absorption" curve is undoubtedly the same as the photosynthetic curve.

The agreement of the observed and calculated efficiencies in the tests comparing red and yellow light explains the photosynthetic differences between the pines grown in red light and those grown in blue light as being due to their different colors. This color difference is in the yellow and not in the red. The absorption spectra of the pigments showed that the color difference is due to differences in the relative amounts of at least two pigments, which was shown by comparing solutions from the two types of trees in a colorimeter.

PHOTOSYNTHESIS IN RELATION TO LIGHT AND CARBON DIOXIDE, *E. L. Smith.* Natl. Acad. Sci. Proc., 22 (1936), No. 8, pp. 504-511, figs. 5. The results of varying light intensity and CO_2 concentration on photosynthesis in the fresh water plant, *Cabomba,* are compared with those of other workers with other plants.

THE INFLUENCE OF LIGHT AND CARBON DIOXIDE ON PHOTOSYNTHESIS, *E. L. Smith.* Jour. Gen. Physiol., 20 (1937), No. 6, pp. 807-830, figs. 8. The author has made extensive measurements with one plant for the effect of CO_2 concentration and light intensity and has compared them with previous data for other plants under conditions showing their basic similarities and differences. Pursuant to this work "an optical system is described which furnishes an intensity of 282,000 meter-candles at the bottom of a Warburg manometric vessel. With such a high intensity available it was possible to measure the rate of photosynthesis of single fronds of *Cabomba caroliniana* over a large range of intensities and CO_2 concentrations.

"The data obtained are described with high precision by the equation $KI = \rho/(\rho^2_{max.} - \rho^2)^{1/2}$, where ρ is the rate of photosynthesis at light intensity I, K is a constant which locates the curve on the I axis, and $\rho_{max.}$ is the asymptotic maximum rate of photosynthesis. With CO_2 concentration substituted for I, this equation describes the data of photosynthesis for *Cabomba* as a function of CO_2 concentration. The above equation also describes the data obtained by other investigators for photosynthesis as a function of intensity, and of CO_2 concentration where external diffusion rate is not the limiting factor. This shows that for different species of green plants there is a fundamental similarity in kinetic properties and therefore propably in chemical mechanism. A derivation of the above equation can be made in terms of half-order photochemical and Blackman reactions, with intensity and CO_2 concentration entering as the first power, or if both sides of the equation are squared, the photochemical and Blackman reactions are first order and intensity and CO_2 enter as the square. The presence of fractional exponents or intensity as the square suggests a complex reaction mechanism involving more than one photochemical reaction. This is consistent with the requirement of 4 quanta for the reduction of a CO_2 molecule." *(Continued on page 336)*

A New Era in Corn Harvesting . . . the *NEW* FARMALL PICKER for the F-12 and F-14

International Harvester engineers have completed another important link in the chain of power farming equipment. This new development is a handy, 1-row mounted corn picker for the smaller Farmall Tractors—the F-12 and F-14. This new machine, known as the No. 1-M, makes picking profitable on small and medium-size farms.

This compact, complete unit, capable of picking 8 to 10 acres a day (300 to 500 bushels), incorporates the basic, time-tested features of McCormick-Deering Corn Picker design with adaptations and improvements.

The picker mechanism is readily mounted on the tractor. A rear delivery elevator loads the corn into a wagon pulled directly behind the tractor. Weight is properly balanced over a subframe parallel with the tractor axle. Substantial bracing running well toward the front end of the unit keeps all parts in perfect alignment.

Snapping rolls are sturdily built with corrugations and fluted heads for aggressive action. The husking roll unit has ample adjustments and is provided with a cleaning fan. Shelled corn is saved and delivered into the wagon. A feature promoting clean husking is the flexible wing-beater above the upper end of the snapping rolls. This beater helps eliminate trash and prevents it from being carried to the husking bed.

Complete details about this new picker and the other models in the McCormick-Deering line will be supplied on request.

INTERNATIONAL HARVESTER COMPANY
(INCORPORATED)
180 North Michigan Avenue Chicago, Illinois

McCORMICK-DEERING

Agricultural Engineering Digest

(Continued from page 334)

MACHINE PLACEMENT OF FERTILIZER FOR COTTON, *H. P. Smith, H. F. Morris, and M. H. Byron.* Texas Sta. Bul. 548 (1937), pp. 52, figs. 23. This bulletin reports investigations which were conducted in cooperation with the USDA Bureau of Agricultural Engineering, the National Fertilizer Association, and the Joint Committee on Fertilizer Application.

It is pointed out that the placement of fertilizer in relation to the cottonseed at the time of planting has a profound influence on the germination of the seed. Experiments were made at Bryan, Temple, College Station, and Nacogdoches, Tex., from 1932 to 1935, to determine the effect on germination and yield when fertilizer is placed under the seed in narrow and wide bands at different depths, when applied at different depths and distances to the side of the seed, when some of the fertilizer is applied in the furrow with the seed, and when fertilizer is applied at different rates per acre and different places in relation to the seed.

The results show that of all placements of fertilizer the best germination of cottonseed and the highest yields were obtained when the fertilizer was placed to the sides and below the seed level. The location of the fertilizer in relation to the seed affected germination more than it did yield. When the fertilizer was placed within 1 in of the seed, germination was injured, as it was too close.

More plants were obtained where one-fourth of the fertilizer was applied in the surface soil over the seed and the balance 2½ in to each side and 2 in below the seed level, but a higher yield was obtained where one-eighth of the fertilizer was applied with the seed and the balance 3½ in to each side and 2 in below the seed level.

When results of applying fertilizer in both wide and narrow bands directly under the seed were compared, the 3-in depth gave the highest number of seedlings for both width bands, but the 2-in depth gave the highest yield for the narrow bands and the 1-in depth for the wide bands.

For 250, 500, and 750-lb rates, the 500-lb rate applied in bands 2½ in to each side and 2 in below the seed level gave the largest number of plants, but the 750-lb rate applied 3½ in to each side and 2 in below the seed level gave the highest yield.

No significant difference in yield was obtained where all of the fertilizer was placed on one side of the seed or where it was divided and equal amounts placed on each side of the seed. The highest yield of 326 lb of lint per acre was obtained for the one-sided placement, as compared with 312 lb for the placement to each side.

When compared with the two unfertilized checks, which yielded 239 and 257 lb of lint per acre, the results show a significant increase from the use of fertilizer for both the one-side and the each-side placements when all four locations are considered. Better response from the use of fertilizer was obtained at College Station and Nacogdoches than at Bryan in the Brazos River bottoms and at Temple.

Disturbing the soil at any depth under the seed without applying fertilizer reduced the final stand of plants as compared with the stand obtained where the soil was undisturbed for a distance of 2½ and 3½ in to each side of the row and no fertilizer applied.

USING THE TRACTOR EFFICIENTLY, *A. W. Clyde.* Pennsylvania Sta. Bul. 343 (1937), pp. 20, figs. 14. This bulletin is a summary of information on the subject from various sources, including the results of work conducted at the station. It presents practical suggestions on how best to use the tractor in the various draft operations.

It is pointed out that a two-plow tractor, in order to be profitable, should replace at least two horses and be used more than 300 hr per year. Other factors discussed are oils, fuels, and factors involved in traction. Special attention is devoted to hitches.

CONTOUR-TRENCHES CONTROL FLOODS AND EROSION ON RANGE LANDS, *R. W. Baile and A. R. Croft.* U. S. Dept. Agr., Forest Serv., Emergency Conserv. Work, Forestry Pub. No. 4 (1937), pp. III + 22, pls. 10, figs. 6. The purpose of this publication is to show the relation of the contour-trench system of flood and erosion control to the broader aspects of upstream engineering applicable to the Intermountain Region, to describe the system in detail, and to give instruction for its application in the field, including methods of analyzing problem areas.

CAMP STOVES AND FIREPLACES, *A. D. Taylor.* U. S. Dept. Agr., Forest Serv., Emergency Conserv. Work, 1937, pp. [9] + 91, pls. 27. This publication contains a large amount of practical information on the subject.

the BADGE of him who BELONGS

DESPITE the *presumption* it sets up, mere membership in the American Society of Agricultural Engineers is no *proof* of a man's high rank in technical talent. It does prove that he has met certain minimum requirements and has earned the esteem of colleagues who sponsored his application for membership.

But the Society emblem is *evidence* that native talent, be it great or small, is enriched by fraternity with the personalities whose minds fuse to form the pattern of progress in the methods and mechanics of agriculture. The wearer of the emblem waits not for the debut of an idea, but is present at its birth and helps to guide its growth.

Be you novice or veteran, your membership in the organized profession adds something to your efficiency, your vision, your influence as an individual engineer. The Society symbol on your lapel is token that you "belong." Wear it.

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With blue ground for Fellows and Members—furnished either in pin with safety clasp or lapel button—$2.00 each.

With red ground for Junior Members, Associates, and Student Members—furnished only in pin with safety clasp—$1.00 each.

Send orders to ASAE, St. Joseph, Michigan.

Literature Received

"ELEMENTS OF STRUCTURAL ENGINEERING," by Edward G. Sheiry, first edition, 1938. X + 476 pages, 5½x8½ in. This book is stated to have been planned as a text for college students not specializing in the subject, and for others interested in a technical treatment of its fundamentals under one cover. Chapters are included on "Loads on Structures," "Reaction, Shears, and Moments for Fixed Loads," "Bar Stresses for Fixed Loads," "Stress Analysis Under Moving Loads," "The Design of Members," "The Design of Connections," "Reinforced Concrete-General Theory," "Reinforced-Concrete Building Design," "Deflection," and "Analysis of Indeterminate Structures." Tables are grouped and additional information furnished in an appendix. Indexed. International Textbook Company.

EMPLOYMENT BULLETIN

The American Society of Agricultural Engineers conducts an employment service especially for the benefit of its members. Only Society members in good standing may insert notices under "Positions Wanted," or apply for positions under "Positions Open." Both non-members and members seeking to fill positions, for which ASAE members are qualified, are privileged to insert notices under "Positions Open," and to be referred to members listed under "Positions Wanted." Any notice in this bulletin will be inserted once and will thereafter be discontinued, unless additional insertions are requested. There is no charge for notices published in this bulletin. Requests for insertions should be addressed to ASAE, St. Joseph, Michigan.

POSITIONS WANTED

AGRICULTURAL AND CHEMICAL ENGINEER, with nine years experience in agricultural engineering teaching and research and two years industrial experience, desires position in either teaching or research. Age 35. Married. PW-289

AGRICULTURAL ENGINEER, 1936 graduate, single, 25 years of age, southern, desires change. Has been in continuous employment since prior to graduation. Experienced in land survey, contour survey and mapping, drainage, dam planning and construction, sanitary and highway engineering and minor construction. PW-291

AGRICULTURAL ENGINEER, recent graduate, available and interested in any job for which he may qualify anywhere in North, Central, or South America. Some experience in construction and pavement of highways, and as clerk to the Secretary of Agriculture, Havana, Cuba. PW-292